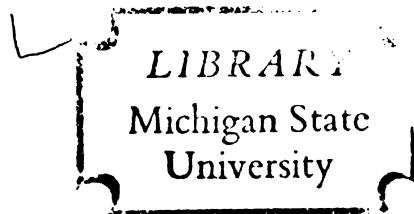


INSECT COMMUNITIES AMONG  
APPALACHIAN MOUNTAIN STREAM BRYOPHYTES

Thesis for the Degree of Ph. D.  
MICHIGAN STATE UNIVERSITY  
JANICE M. GLIME

1968

THESIS



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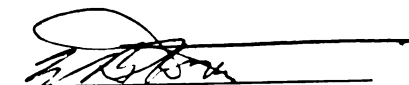
Insect Communities Among Appalachian Mountain  
Stream Bryophytes.

presented by

Janice M. Glime

has been accepted towards fulfillment  
of the requirements for

Ph.D. degree in Botany

  
Major professor

Date

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## ABSTRACT

### INSECT COMMUNITIES AMONG APPALACHIAN MOUNTAIN STREAM BRYOPHYTES

By Janice M. Gline

The primary purpose of this study was to survey the insect fauna of Appalachian Mountain stream bryophytes. From this information, certain implications of community relationships, adaptations, and uses appeared.

Streams were sampled by hand grabs at arbitrary times and at varying frequencies. Dry weight is the base used for quantifying the data.

Among the 28 streams studied in Pennsylvania, Maryland, and Virginia, three bryophyte-based streams are apparent: Fontinalis, the Hygroamblystegium group, and Scapania. A Fontinalis stream is generally larger and has a continuous flow of water sufficient to submerge the moss year-round. Probably due to its larger size, Fontinalis houses the larger of the bryo-insects, but smaller ones occur here too. The Hygroamblystegium group comprises streams where several species of bryophytes appear similar and make similar mats. Both their insect faunas and the narrow, shallow streams they occupy are similar. These mats provide homes for small insects. Scapania streams were only represented by two, but among all the Scapania collections the insects were small. In Toliver Run, Scapania exhibited more species and individuals of insects than Fontinalis in that same stream.

The most important bryo-insects, numberwise, appear to be Diptera (Chironomidae and Simuliidae), while Ephemeroptera, Plecoptera, and Trichoptera are of secondary importance. But even these secondary orders may exhibit disproportionately high numbers in individual streams or during certain seasons.

As indicated by the seasonal trends in sizes, kinds, and numbers of insects, one use of the bryophyte appears to be that of a nursery--

a substratum where hatchlings develop in protected chambers with a flowing food supply. Other insects living there are tiny even until they emerge from the water. This adaptation of small size is often accompanied by such adaptations as lateral compression, covered gills or lack of gills, lack of appendages, or hooks for attachment.

As a result of this study, 150 insect taxa have been named from bryophyte habitats, while only about 70 are common enough to be considered true bryo-insects. Among these, most collections have about 15-20 species. Two of the caddis fly larvae appear to represent new genera of the families Hydroptilidae and Brachycentridae.

INSECT COMMUNITIES  
AMONG  
APPALACHIAN MOUNTAIN STREAM BRYOPHYTES

By

Janice M. Glime

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Dr. Clyde F. Reed, Baltimore; Dr. Harold Robinson, Smithsonian Museum; Dr. Howard Crum, University of Michigan; Dr. Winona Welch, DePauw University (Fontinalis).

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While writing the thesis, I appreciated suggestions of Dr. Kenneth Cummins of Pymatuning Laboratory and Dr. Thomas Waters of the University of Minnesota, while Dr. Herman Struck of the Michigan State University English Department criticized the structure of the writing.

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## INTRODUCTION AND LITERATURE REVIEW

Streams, bryophytes, insects: all these have been studied by many authors, but few have studied the interrelationships of the three in depth. (Thienemann, 1912; Carpenter, 1928; Percival and Whitehead, 1929, 1930; Illies, 1952; and Minckley, 1963 all included mosses in their discussion of stream surveys.) Moreover, even fewer workers have attempted to determine the relationships among insect communities associated with bryophytes in different streams or among several species of bryophytes. Only Frost (1942) compared the fauna of mosses in an acid and an alkaline stream, but she did not separate the moss species in her analysis. Thus, the present study appears to be the first attempt to compare the bryophyte fauna of streams of the Appalachian Mountains in the Deciduous Forest Formation (Braun, 1964).

As the first study of its kind in the Appalachian area, this study is an attempt to determine some of the natural history relationships existing in the bryophyte-insect communities of flowing water in 28 middle Appalachian streams. Among the possible aspects for study, several basic ones were chosen: 1) determination of common bryophyte taxa; 2) observation of ecological aspects of the streams where these bryophytes occur; 3) observation of types of substrata which these bryophytes provide (e. g. mat, streamer) for insects; 4) determination of taxa of insects to be found among these bryophytes; 5) observation of any apparent adaptation of insects to the bryophyte habitat; 6) consideration of possible uses of the bryophyte by the insects; 7) determination of the most frequent insects; 8) observation of recurrent arrays of insect species; 9) determination of aspects which appear to warrant detailed further study.

For the purposes of this study, the bryophytes themselves were the only substratum of the stream to be considered. Since bryophyte rhizoids do not appreciably penetrate the rock, the plants themselves form the observable physical boundaries. But even in so simple a system, different habitat zones can be detected, e. g., basal, surface, and mat, and the boundaries of these zones blend in problematic transitional areas. In this study, the entire moss stand is considered as the community, and these habitat zones are recognized as habitats within the community, but they are not considered individually in the analysis. Because insects may pass easily from the surface zone to open water and back again, the bryo-community fauna is herein defined as those organisms which remain with the bryophyte when it is collected.

In addition to having the advantage of physical and biological boundaries, this community study is one of the few attempts (according to Whittaker, 1962) to use invertebrate-plant relations as a means of defining a community, but it neglects other vital members of the community such as plankton, epiphytes, and other arthropods. In Whittaker's coverage of literature on community studies, he states that marine and littoral communities have been based on dominant animals (Shelford and Towler, 1925; Newcombe, 1935; Clements and Shelford, 1939), but "Characterization of terrestrial biomes by invertebrate animals has been scarcely attempted." These terrestrial biomes are usually delimited by their plant composition (Shelford, 1963; Braun-Blanquet, 1965) and dominance (Braun, 1964; Shelford, 1963; Oosting, 1956), while invertebrates are usually ignored. Ross (1963) is an exception. By comparing the distribution of aquatic insects with terrestrial plant biomes, he found that certain insect genera had the same distribution pattern as

dominant plants of the biome, e. g. Acer saccharum Marsh., and that for several caddisfly genera the distribution coincided with a terrestrial biome. This he found was particularly true of smaller streams: that factor influence (leaf fall, runoff, shade, temperature, rainfall) is inversely related to stream size; therefore, larger streams are more similar to those of other biomes; smaller ones are unique. Furthermore, biota of small streams are more restricted in their composition.

Aside from the biome treatment of terrestrial systems, stream biologists attempt to describe stream affinities on the basis of physical, chemical, and biological similarities (Ricker, 1934; Van-Deusen, 1953; Frost, 1942). To compare members of a single stream system, Harrel (1966) correlated species diversity indices with stream order (Horton, 1945; Leopold, 1962. Stream order refers to the number of tributary junctions.) in the Otter Creek system, northcentral Oklahoma. Furthermore, he found that physico-chemical conditions of Otter Creek were closely related to stream order. That location of a stream in the drainage basin is important in regulation of community structure is evidenced by a third order adventitious stream which flows directly into the sixth order stream of the Otter Creek system. Contrary to expectation, this third order stream exhibits greater similarity to higher order streams than to other third order streams.

To provide a common system of classification for plant and animal communities, Klugh (1923) listed 30 associations, each of which he further dissected into systases and cenoses. He is his own best critic of the system when he states that "lines have to be drawn where no hard and fast lines exist, and it must be borne in mind that the ecotone...is usually a blending and not a sharp line." According to

his system, streams would be in the Spring Association or Stream Association, and these are further divided on the basis of flow, position in stream (plankton, surface, bottom), and bottom type. By his classification the stream bryophyte could be in the Stream Association as an Emophyte Cenosis of a Slow-flowing Stream (Tachydromile Systasis), or in the Spring Association as part of the Rapids Cenosis. On the other hand, some workers (Ricker, 1934; Percival and Whitehead, 1929) refer to a moss region of a stream, encompassing all of these societies at once.

The literature abounds with faunal studies of stream communities. In many studies fish have been used to describe the regions of the stream (Ricker, 1934; Huet, 1949; VanDeusen, 1953; Kuehne, 1962). Others have used upper, middle, and lower reaches and described the invertebrate species within these (Berg, 1948; Wilburn, 1964). But because of the difficulty of delimiting any one community, few studies actually compare fauna among different streams. Further complicating the problem of comparison are tremendous variations of physical and chemical attributes and the necessity for different sampling methods in different streams. Because the present study uses a biological boundary rather than a physical one, it is possible that the requirement of bryophyte presence leads to greater homogeneity than one kind of physical or chemical stream type. I expected that any given species of bryophyte would itself be limited to certain streams and regions within these streams by certain chemical and physical factors, and thus encompass communities with more uniform abiotic conditions. When Frost (1942) compared an acid and an alkaline stream, she found Fontinalis squamosa Hedw. to be the dominant moss in the acid stream (90 per cent of the bryophytes by weight), while Fontinalis antipyrene-

tica and Eurynchium riparioides were the dominant mosses in the alkaline one (51.3 per cent and 42.4 per cent of the bryophytes respectively). Not only mosses differed between the chemically different streams; invertebrates were represented by different species as well. In the present study bryophyte patches were not found in all streams nor in all situations in the streams of occurrence. Furthermore, the bryophyte species differed in different situations. I therefore expect the biological heterogeneity throughout patches of any given bryophyte species might be lower than throughout a single physically delimited habitat type.

## METHODS AND PROCEDURES

### Choice of Site and Sampling Procedure

To compare bryo-communities in a wide variety of streams, collections were made in three states in the Appalachian Mountains: Pennsylvania, Maryland, and Virginia (Plate 1). Here, any stream encountered could be included if it had submersed bryophytes in flowing water. As it was soon discovered, mountain and high elevations were most likely to have bryophyte regions in their streams, so for expediency, most collecting sites were selected in these areas. Areas of apparent pollution or disturbance were eliminated. Most of the streams could be sampled only once (primarily March and summer, as noted later), but year-round collections (March, May, June, July, August, and December) were made in Garrett County, Maryland, where small, medium, and large streams permit a wide variety of habitats.

In any comparative community study, it is desirable to have a uniform sample size. To accomplish this, previous workers collected a specified area (Minckley, 1963) or attempted to estimate a uniform weight in the field (Frost, 1942). Later, Frost's weight samples were reduced to the specified weight (200 gms. wet weight) in the lab. But in the present study collecting in many streams and many seasons made it impractical to choose a uniform sample size: 1) In winter, a large sample of bryophytes was never available. 2) Some streams have abundant growth while others have little. 3) Some bryophytes, such as Fontinalis, were usually in large quantities, but others, such as Scapania, were frequently scarce. 4) Volumetric and area

samples were impractical because of the irregular surface of the substratum and the varying thickness of the bryophyte mat.

On the basis of trials with various sampling techniques and equipment, the method of hand sampling was chosen. By the simplest possible means, the collector merely scrapes off a "handful" of bryophyte with his fingers. (These samples range from .5 to 12 grams, where the low weights usually are Scapania and the Hygroamblystegium group, while higher ones are for Fontinalis. The area sampled ranges from 20 to 100 square centimeters, occasionally reaching 200 square centimeters for Fontinalis.) To obtain a quantitative measure of the amount of bryophytes present, every sample is weighed on a torsion balance after removal of insects and air drying. To compare the dry weight with the wet weight used by Frost (1942), four samples each of three bryophytes were also weighed wet with the following factors of wet X dry weight: Fontinalis 2.9-4.7, mean 3.8; Scapania 4.4-6.7, mean 5.2; Hygroamblystegium group 3.8-8.5, mean 5.8. The overall mean is 4.9. The wet weight was obtained for this study by holding the bryophyte out of the water until it seemed to have stopped dripping, then weighing it.

There are several sources of error which might result from this handful method: 1) insects, especially the more active swimmers, may be lost as the sample is removed; 2) the handful is variable in cross section and height, and increase in sample size by weight may not correspond to an increase in number of insect individuals; 3) the number of species of insects may be related to the sample size; 4) equal weights of different species of bryophytes may not be comparable in terms of substratum availability for insects.

To provide a rough estimate of the loss of insects during sampling, a screen was placed immediately downstream from a Fontinalis clump in Ginseng Run and a handful of moss was collected. The number of insects reaching the screen was less than .6 per cent of the number remaining in the collection ( Baetis; 2 simuliids); repetition produced the same results. Furthermore, it is possible that these insects were dislodged from adjacent mosses in the clump rather than from the sample. Because of its very loose, open nature, Fontinalis was thought to be more likely to lose insects during collections than the other bryophytes. Thus, an estimate of less than 1 per cent loss may not be unreasonable. Of course, for the surface zone component alone the percentage loss would be much higher.

By increasing sample size, intuitively one expects to increase the number of individuals correspondingly (Arrhenius, 1921). Since many other variables were influencing numbers of insect individuals and species present in a bryophyte sample, and the bryophyte samples themselves were scarcely uniform in bottom area sampled or bryophyte surface area or bryophyte weight, it is difficult to show the effect of sample size on numbers of individuals. But when many samples are combined and presented graphically, general patterns of stream differences, abundance differences among the various insects, and associations between particular bryophytes and particular insects can be inferred.

There is no way to adequately determine the relationship of the number of insect species to the size of the handful sample, for numbers of insect species could also be related to basal area, bryophyte surface area, volume, or a combination of these. If weight is accepted as proportional to surface area, it serves as one measure of size relationship. In Fig. 1, we see that there is the expected increase

Figure 1. Comparison of number of species against number  
of grams of bryophyte.

F Fontinalis dalecarlica

H Hygroamblystegium fluviatile

S Scapania undulata

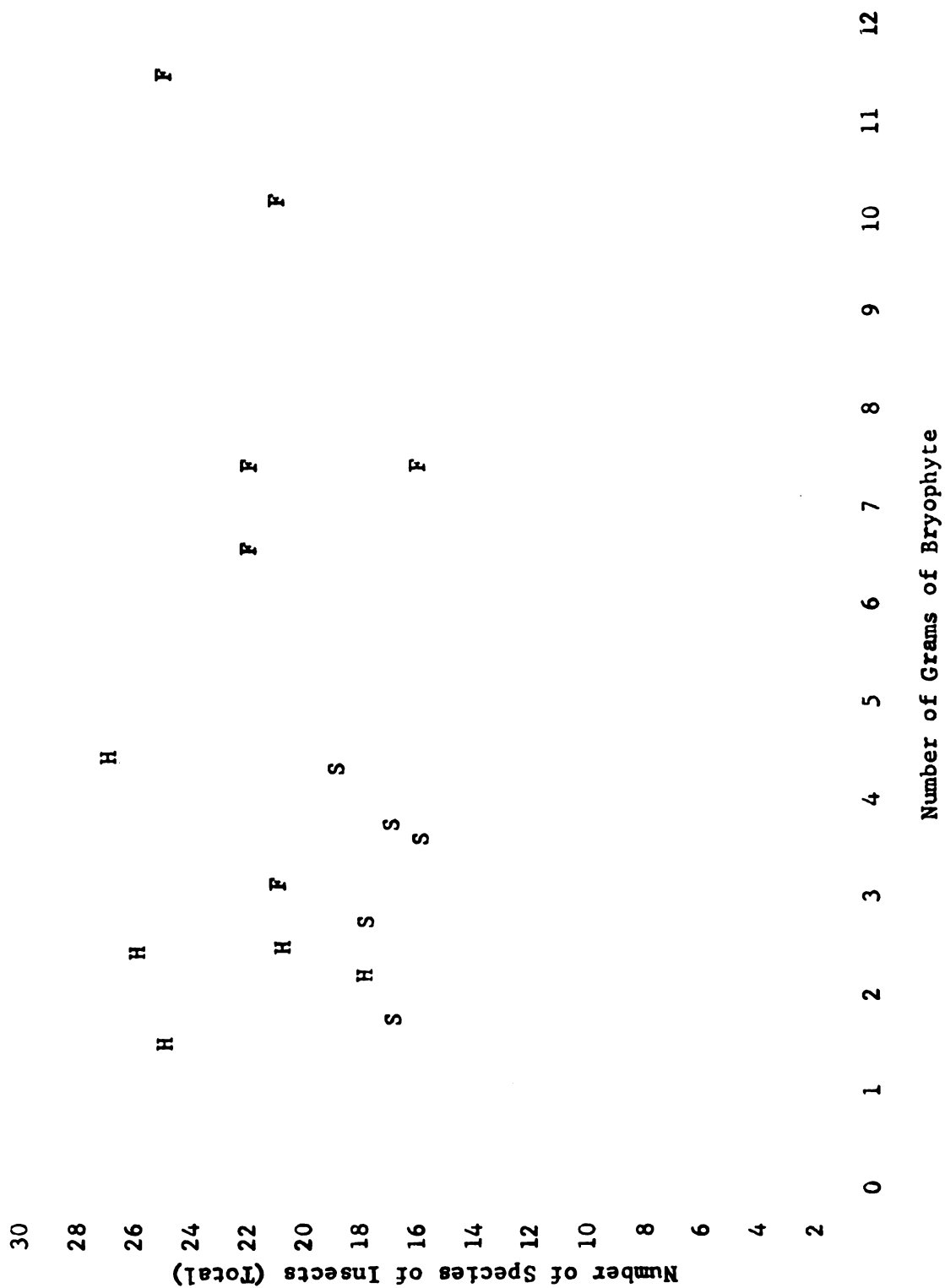


Figure 1.

in number of insect species with increase in weight (determined from several samples of one species in one stream on the same date). But it is possible that basal area, and likewise volume, may reflect upon the quantity and kind of food passing through the bryophyte mat, and thus influence the number of species, as well as the number of individuals.

That different species of bryophytes might have different weight to available substratum ratios is a difficult problem to resolve. Even if we consider weight as a measure of biomass available to a food chain, we have the problem of comparing quality of food. However, if weight is assumed to be correlated with bryophyte surface area, we know many reasons why the relationship might be very complex. Factors such as tissue density, total plant surface area, leaf to stem ratio, plant form, and nature of growth (mat, trailing, etc.) contribute to the bryophyte influence on the insect community. Of the parameters cited above, weight is easiest to measure, and dry weight is more replicable. In spite of its limitations, air dry weight is the measure of the bryophyte biomass present in each hand-ful in this study.

#### Preservation and Sorting

At the time of collection, wet bryophytes were placed in jars (usually baby food jars) without addition of stream water, labelled inside with pencil on cards, and numbered. Upon return to the lab, 95 per cent alcohol was added to all collections. Duplicates of the label information and collection data were kept in a bound notebook, while a separate bound notebook was used to record stream descriptions and observations in the field.

The large bulk of material to be sorted necessitated the use of technicians who removed the insects from the bryophytes and placed the insects in 2-dram vials with 70 per cent alcohol for later resorting, identification, and counting. Collections sorted by the technicians were checked until the technician's effectiveness seemed to be about the same as my own; later the technician's work was occasionally spot checked. Nevertheless, I sorted 95 per cent of the material for this study myself, while my main technician sorted 90 per cent of the remainder.

All sorting except in the counting chamber was done with a dissecting microscope at 10X magnification.

#### Counting Chamber

When their numbers are sufficiently high, Chironomidae require special sorting techniques. In such instances a counting chamber permits counting at 20X magnification. The chamber consists of a petri dish with straight lines scratched .25 inches apart on the bottom. By placing the insects in the lid and anchoring the lined bottom inside the lid with paper clips, one can move the petri dish back and forth for counting without disturbing the insects' positions. Comparison between a hand-count and chamber count of the same sample showed less than five per cent lower count by chamber counting.

Even the latter method is more time-consuming than seems justified because the Chironomidae are nearly always highest in abundance among the insects. Because insects settle toward the bottom of the jar, representative subsampling is impossible. Consequently, the alternative procedure for the extremely abundant samples is to sample a

few chironomids, but leave the bulk of them on the bryophyte without counting them. This reduces sorting time by 50 to 70 per cent. When chironomids are low in numbers or are not obviously the most abundant, they are all removed from the bryophyte and counted with a hand counter, as are all other insects.

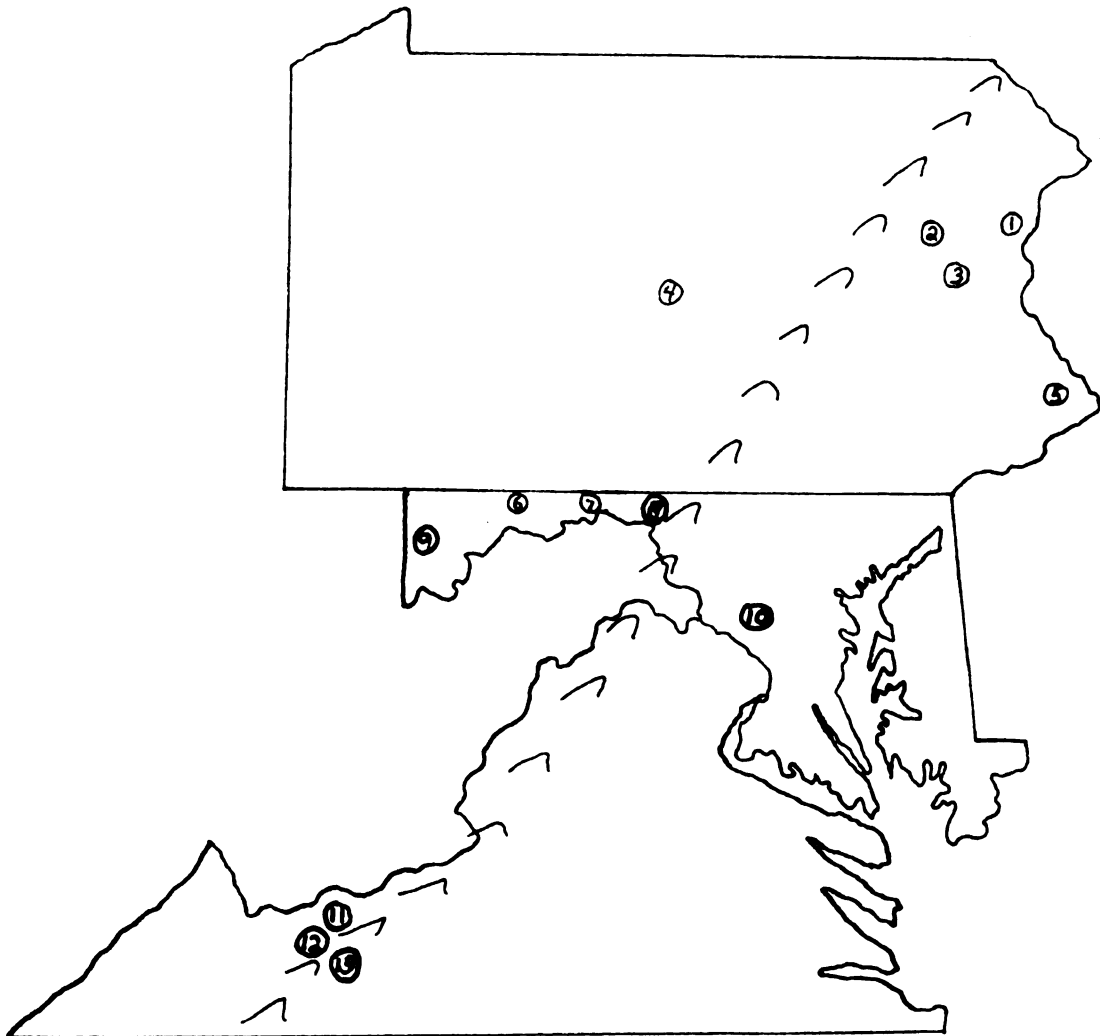
#### Stream Data

Because so many streams are included in this study, and only a few sampled throughout the year, no specific attempt was made to link stream chemical characteristics to the bryophyte-insect associations. U. S. Weather Bureau Climatological Data (Climate and Man, 1941) provide the temperatures and growing seasons (Plates 2-6), while U. S. Geological Survey maps provide the elevations and rock types, except where other references are cited. It is possible to obtain an average elevation gradient for the stream by using maps to measure distance from most distant source to the collection site and dividing this into the difference in elevations. Stream order is determined by the number of tributary junctions (Leopold, 1962).

## PLATE 1. MAP OF STREAM LOCATIONS

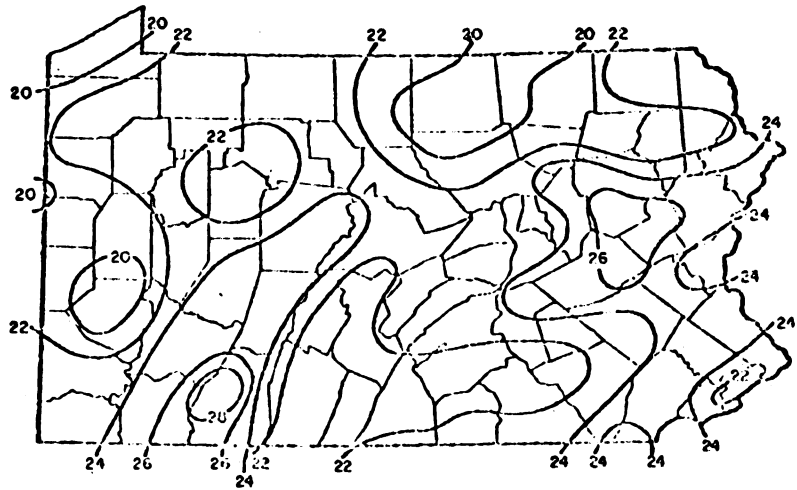
1. Saw Creek and Dingman's Creek
2. Mud Run and tributaries
3. Pohopoco Creek
4. Elk Creek
5. Pidcock Creek
6. Piney Creek
7. Gramlich Run
8. Sideling Hill Creek tributary
9. Youghiogheny River system
10. Little Bennett Creek and Seneca Creek tributaries
11. Sinking Creek and Johns Creek
12. Mountain Lake tributary to Sinking Creek
13. Rock Castle Creek and Goose Creek

## PLATE 1



3

## PLATE 2

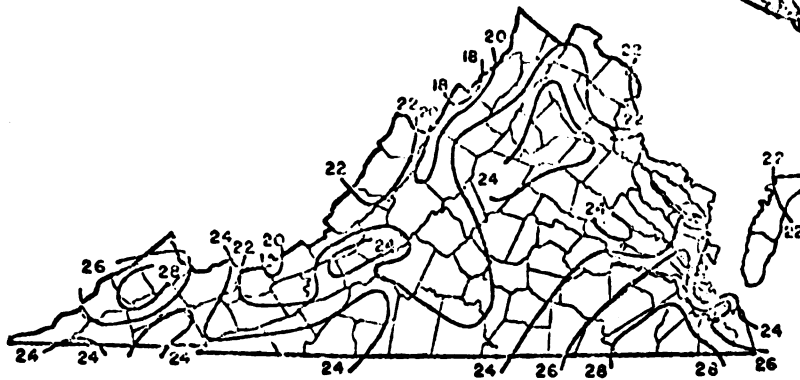
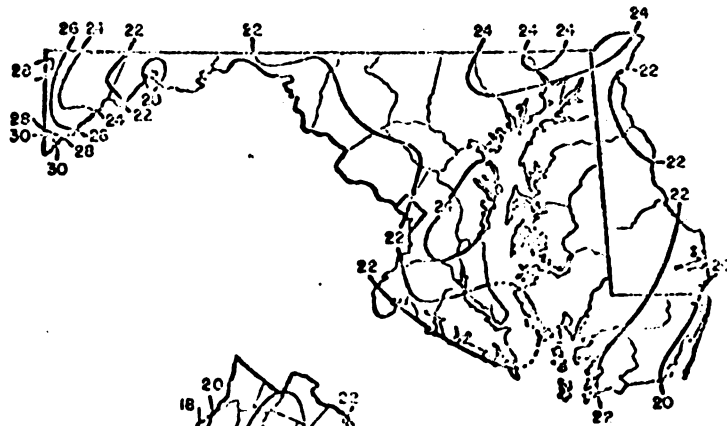


## PENNSYLVANIA

AVERAGE WARM-SEASON PRECIPITATION (INCHES)  
(APRIL TO SEPTEMBER, INCLUSIVE)

## MARYLAND AND DELAWARE

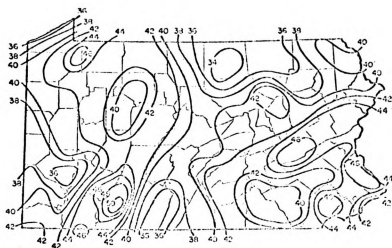
AVERAGE WARM-SEASON PRECIPITATION (INCHES)  
(APRIL TO SEPTEMBER, INCLUSIVE)



## VIRGINIA

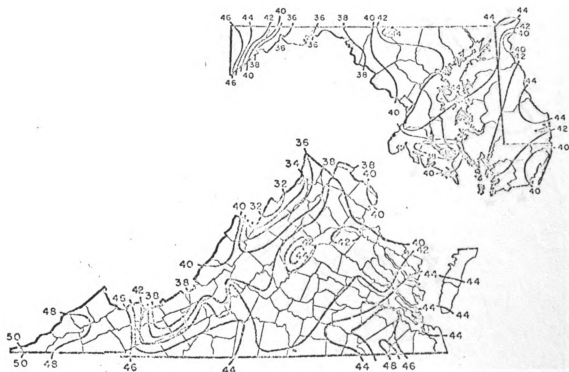
AVERAGE WARM-SEASON  
PRECIPITATION (INCHES)  
(APRIL TO SEPTEMBER, INCLUSIVE)

## PLATE 3



## PENNSYLVANIA

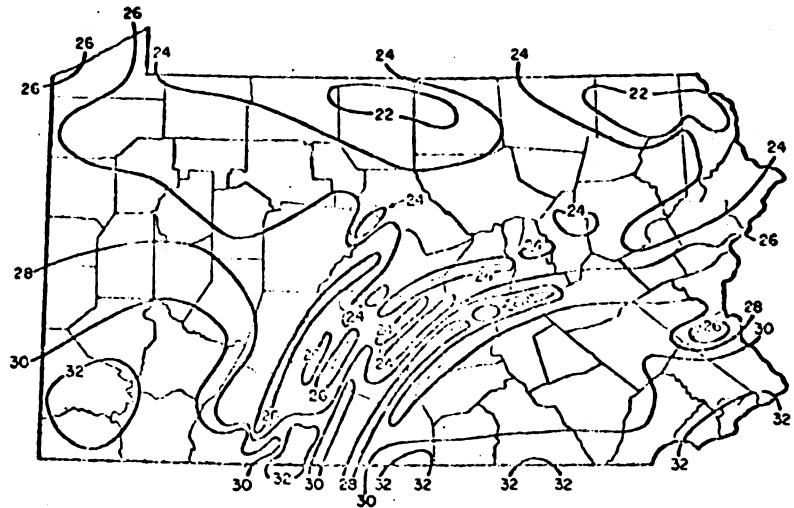
AVERAGE ANNUAL PRECIPITATION (INCHES)

MARYLAND AND DELAWARE  
AVERAGE ANNUAL PRECIPITATION (INCHES)

## VIRGINIA

AVERAGE ANNUAL PRECIPITATION (INCHES)

PLATE 4

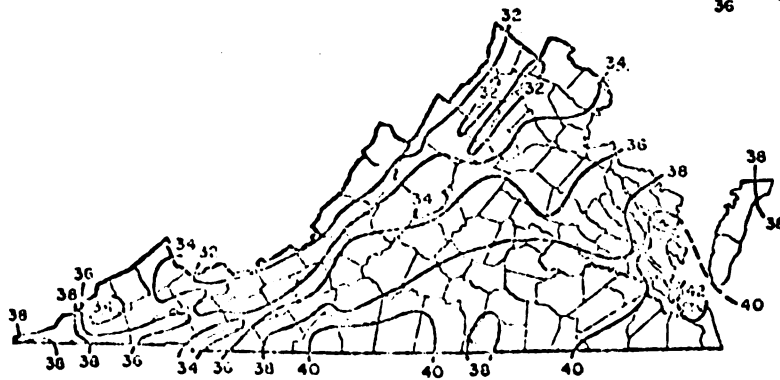
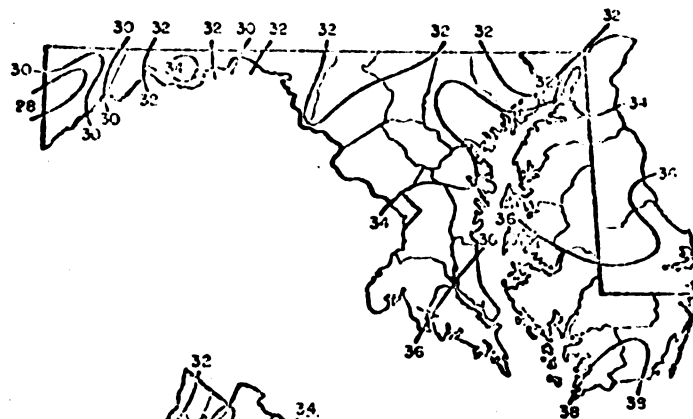


PENNSYLVANIA

AVERAGE JANUARY TEMPERATURE

MARYLAND AND DELAWARE

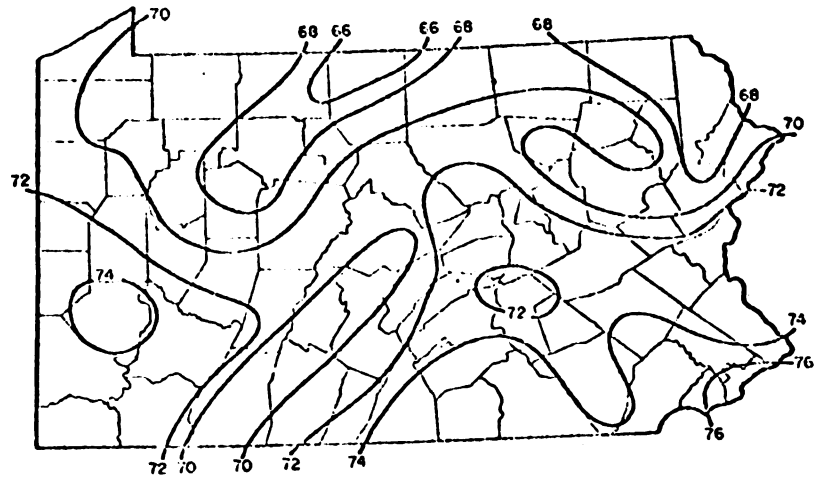
AVERAGE JANUARY TEMPERATURE



VIRGINIA

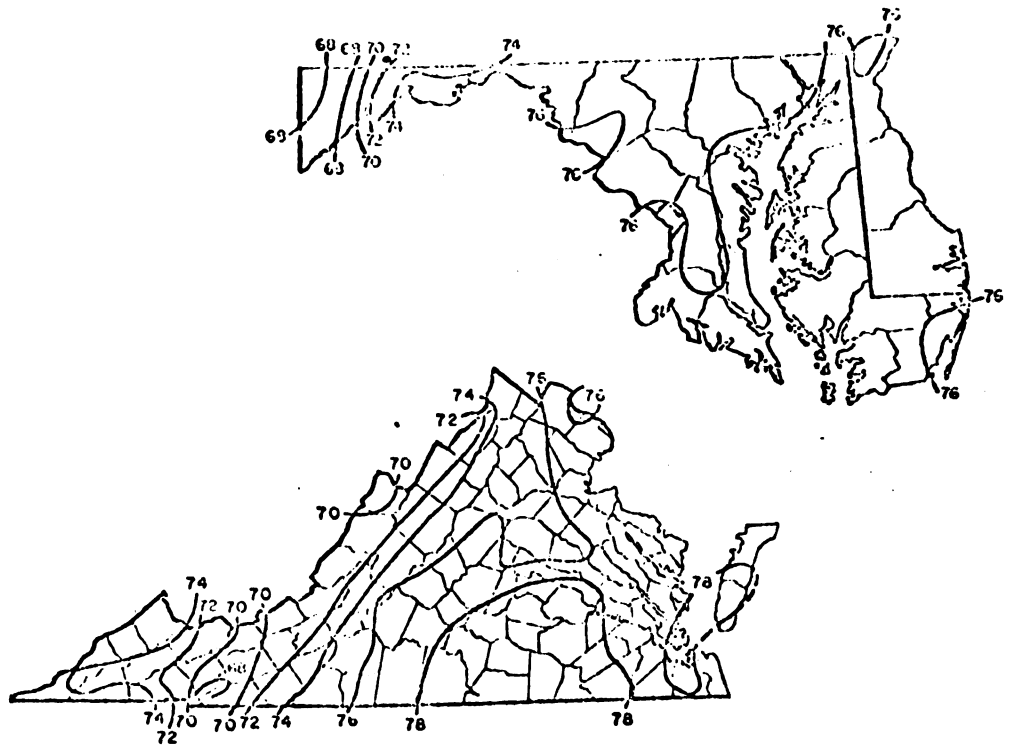
AVERAGE JANUARY TEMPERATURE

PLATE 5



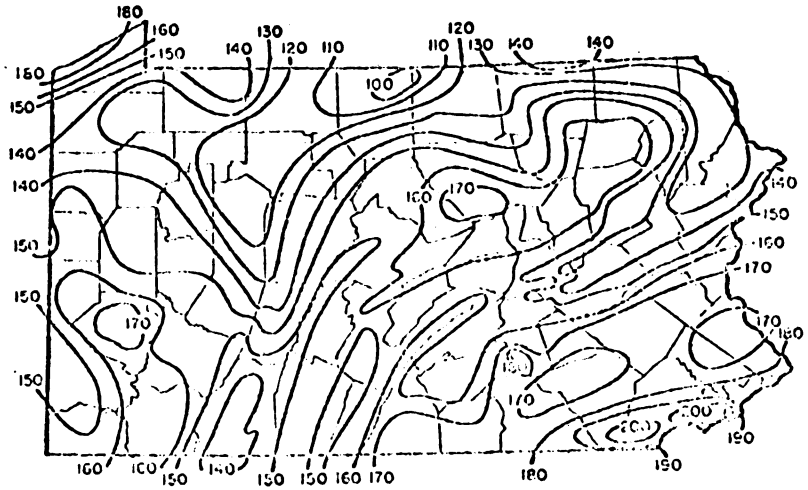
PENNSYLVANIA  
AVERAGE JULY TEMPERATURE

MARYLAND AND DELAWARE  
AVERAGE JULY TEMPERATURE



VIRGINIA  
AVERAGE JULY TEMPERATURE

## PLATE 6

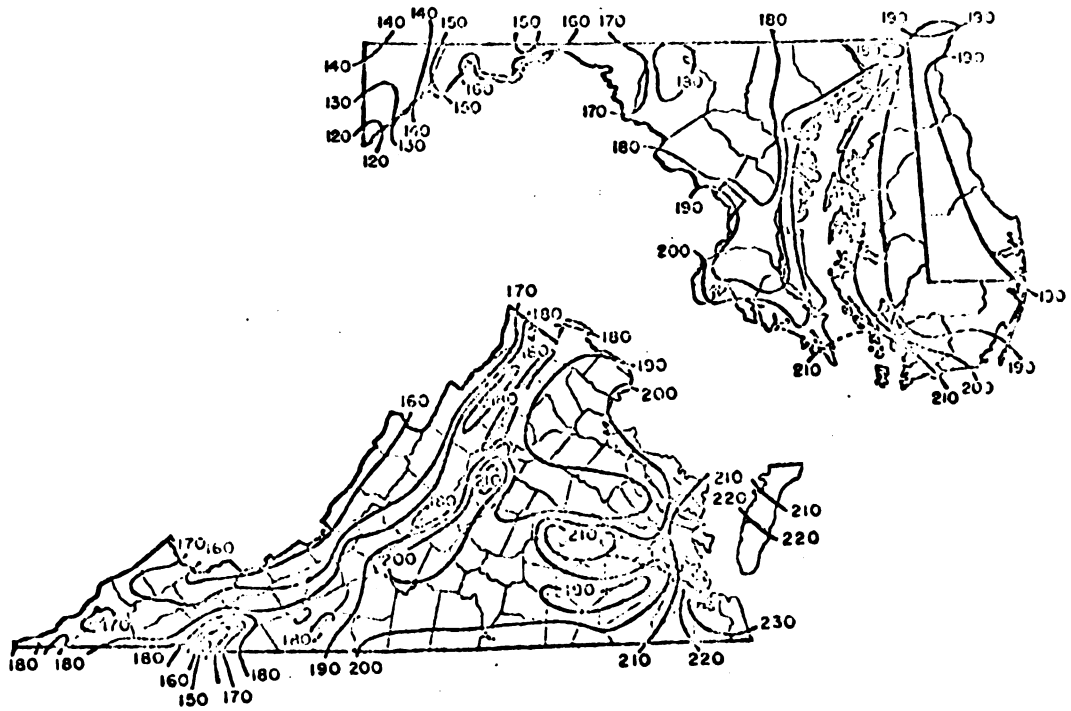


## PENNSYLVANIA

AVERAGE NUMBER OF DAYS WITHOUT KILLING FROST

## MARYLAND AND DELAWARE

AVERAGE NUMBER OF DAYS WITHOUT KILLING FROST



## VIRGINIA

AVERAGE NUMBER OF DAYS  
WITHOUT KILLING FROST

## RESULTS AND DISCUSSION

In the upper reaches of the Appalachian Mountains, cool, rapid streams find their origin where springs, surface runoff, and ground water insure a continuous flow throughout the year. Because of these factors, coupled with the shading effect of deciduous forest trees, the area is an ideal one for stream bryophytes. Yet there is sufficient variation in stream size, gradient, chemistry, and substrate to permit a comparative study. Plates 2-6 show USGS climatological data. Table I lists the species of bryophytes, while Table II gives a tabular summary of some of the physical data and bryophytes for each stream.

The streams contributing to this study are in Pennsylvania, Maryland, and Virginia. For purposes of ecological comparison, these can be grouped in many ways: geography, stream order, elevation, climate, rock type, chemistry, dominant organisms. Because this study is concerned with bryophyte communities, the streams are herein grouped by dominant bryophyte (used here as the bryophyte composing over 50 per cent of the bryophyte cover as observed at the collecting sites). Thus, four bryophytes appear to be dominant bryophytes in the streams chosen: Fontinalis dalecarlica, Scapania undulata, Sciaromium lescurii, and the Hygroamblystegium fluviatile group. The latter is a group of species in which H. fluviatile is usually present with one or more other bryophytes, and the insect species composition for these is quite similar, as well as the streams they occupy. Furthermore, the bryophytes of this group all form a similar mat, varying from rough to smooth, but all compact.

## TABLE I

## TAXONOMIC LIST OF BRYOPHYTES

## Mosses\*

- Amblystegium varium (Hedw.)
- Brachythecium plumosum (Hedw.) BSG
- Brachythecium rivulare BSG
- Bryhnia novae-angliae (Sull. & Lesq.) Grout
- Eurynchium riparioides (Hedw.) Rich.
- Fissidens bryoides Hedw.
- Fissidens cf. minutulus Sull.
- Fontinalis antipyretica Hedw. var. gigantea (Sull.) Sull.
- Fontinalis dalecarlica Schimp. ex BSG
- Fontinalis flaccida Ren. & Card.
- Grimmia alpicola Hedw. var. rivularis (Brid.) Broth.
- Hygroamblystegium fluviatile (Hedw.) Loeske
- Hygroamblystegium fluviatile (Hedw.) Loeske var. orthocladon  
(P. Beauv.) Crum, Steere & Anderson
- Hygroamblystegium tenax (Hedw.) Jenn.
- Hygrohypnum luridum (Hedw.) Jenn.
- Hygrohypnum ocraceum (Turner) Loeske
- Leskea cf. gracilescens Hedw.
- Sciaromium lescurii (Sull.) Broth.
- Sematophyllum carolinianum (C. Mull.) Britt.
- Sematophyllum marylandicum (C. Mull.) Britt.
- Thuidium delicatulum (Hedw.) BSG

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\*Names and authors are according to Crum, Steere, and Anderson, 1965.

## Liverworts

Conocephalum conicum (L.) Dum.

Frullania sp.

Marsupella sphacelata (Gieseke) Dum.

Riccardia sinuata (Dicks.) Trev.

Scapania nemorosa (L.) Dum.

Scapania undulata (L.) Dum.

Plagiochila?



| Stream Type       | Stream | Bryophytes |     |       | Stream Order | Width  | Depth | Elevation at Site | Source Elevation | Distance to Source | Elevation Gradient |
|-------------------|--------|------------|-----|-------|--------------|--------|-------|-------------------|------------------|--------------------|--------------------|
| Scapania          | Hk     | Sp         | F   |       | 1            | 2-10'  | 0-1'  | 1480'             | 1680'            | 1.8 mi.            | 111'/mi.           |
|                   | La     | Sp         | F   |       | 1            | 2-10'  | 0-1'  | 1580'             | 1710'            | 1.9 mi.            | 68'/mi.            |
|                   | To     | Sp         | F   |       | 3            | 15-30' | 0-2'  | 2280'             | 2600'            | 3.0 mi.            | 127'/mi.           |
|                   | Md     | Sp         | F   |       | 3            | 30-40' | 1-2'  | 1540'             | 1840'            | 3.5 mi.            | 86'/mi.            |
|                   | My     |            | F   | F1 Hg | 3            | 30-40' | 1-2'  | 2300'             | 2780'            | 3.8 mi.            | 126'/mi.           |
|                   | Ne     |            | F   | F     | 2            | 4-5'   | 0-1'  | 2500'             | 2600'            | .6 mi.             | 167'/mi.           |
|                   | Po     |            | F   | F1 E  | 1            | 10-15' | 0-1'  | 960'              | 1040'            | .6 mi.             | 133'/mi.           |
|                   | Sw     |            | F   | F     | 1            | 3-6'   | 0-1'  | 1540'             | 1720'            | 1.8 mi.            | 100'/mi.           |
|                   | De     | Sp         | B H | F1 Hg | 1            | 0-3'   | 0-1'  | 2500'             | 2600'            | 2.8 mi.            | 36'/mi.            |
|                   | Di     |            |     | E     | 2            | 10-20' | 0-2'  | 385'              | 1270'            | 7.0 mi.            | 126'/mi.           |
| HYGROAMBLYSTEGIUM | El     |            | H   | Hg    | 3            | 20-30' | 0-2'  | 1300'             | ?                | 13.0 mi.           | ?                  |
|                   | Gl     | Sp         | H F | F1    | 2            | 3-6'   | 3-10" | 2040'             | 2620'            | 3.0 mi.            | 194'/mi.           |
|                   | Go     |            | B H | E     | 3            | 8-12'  | 8-18" | 2180'             | 2640'            | 2.3 mi.            | 200'/mi.           |
|                   | Gr     |            | B H | F     | 2            | 3-7'   | 0-2'  | 1000'             | 1800'            | 2.0 mi.            | 400'/mi.           |
|                   | Hy     |            | H   | F1    | 2            | 3-6'   | 3-10" | 2040'             | 2500'            | 2.5 mi.            | 184'/mi.           |
|                   | Jo     |            | H   | F     | 1            | 10-20' | 1-2'  | 1950'             | 2650'            | .9 mi.             | 778'/mi.           |
|                   | Lb     |            | B H |       | 1            | 1-3'   | 3-5"  | 660'              | 710'             | .3 mi.             | 167'/mi.           |
|                   | Mt     |            | B H |       | 1            | 1-2'   | 0-6"  | 2500'             | 2500'            | .8 mi.             | 1333'/mi.          |
|                   | Py     |            | H   | F     | 1            | 20-30' | 6-18" | 2360'             | 2560'            | 2.8 mi.            | 71'/mi.            |
|                   | Rk     |            |     | E     | 2            | 10-15' | 1-2'  | 1400'             | 2940'            | 8.0 mi.            | 193'/mi.           |
| SCALAROMBIUM      | Sa     |            | F   | Hg E  | 3            | 20-30' | 0-1'  | 440'              | 1350'            | 12.0 mi.           | 76'/mi.            |
|                   | Sat    |            | F   | E     | 1            | 2-3'   | 0-1'  | 440'              | 440'             | *                  | *                  |
|                   | Sd     |            | B   |       | 3            | 8-12'  | 0-1'  | 670'              | 1200'            | 2.5 mi.            | *                  |
|                   | Sk     |            | B H |       | 3            | 15-20' | 1-2'  | 1900'             | 2500'            | *                  | 8'/mi.             |
|                   | WBe    |            | Br  |       | 1            | 1-2'   | 0-6"  | 750'              | 750'             | *                  | *                  |
|                   | WBU    |            | H   |       | 1            | 2-3'   | 0-6"  | 510'              | 750'             | 1.3 mi.            | 185'/mi.           |
|                   | Pi     |            |     | F:    | 1            | 3-7'   | 6-12" | 100'              | 200'             | 1.5 mi.            | 67'/mi.            |
|                   | Tot    | Sp         |     | Sm    | 1            | 3-4'   | 3-5"  | 2300'             | 2415'            | .8 mi.             | 144'/mi.           |

The method of grouping bryophytes by form or type of mat is not unique. European bryologists (Gimingham and Birse, 1957) have attempted this procedure by describing life form, primarily based on terrestrial bryophytes. By their system, four life forms applicable herein have been described: rough mats (Mr)--Brachythecium rivulare; smooth mats (Ms)--Eurynchium riparioides; short turfs (t)--Fissidens bryoides; tall turfs (Te)--Plagiochila asplenioides.

Because Brachythecium rivulare and Eurynchium riparioides should be separated by the above system (Gimingham and Birse, 1957), they present a problem in this study, wherein they have been included in the same group. Jovet (1932), in his work with French streams, comments that the leaves of B. rivulare are a beautiful, fresh bronze, and their arrangement recalls that of Eurynchium riparioides, whereas the singular Brachythecium rivulare on the rocks of la Petite Cascade has julaceous branches simulating E. riparioides, while other leaves resemble Amblystegium riparium. Because of this variability of E. riparioides and the others included with it in this study, I believe they might more practically be included in one group as "mats." However, I have separated one other group (Sciaromium lescurii) because it can generally be named as a dominant rather than as a co-dominant. Sciaromium forms a more open mat and was detritus-covered in shallow, slow streams included in this study; its insect community appears sufficiently different to warrant a separate consideration.

In this study, the "short turf" (Fissidens bryoides) occurs at the bases of other plants, so that it does not warrant its own designation as a stream type. The "tall turf," considered by Gimingham and Birse (1957) to resemble Plagiochila asplenioides, could include

the leafy liverworts of this study, especially Scapania undulata. These turfs form an open mat more like a loose sponge than a true mat.

The truly aquatic Fontinalis remains to be classified. This moss does not form a compact mat, but rather dangles, or nearly floats, in the moving water. I have given this type the singular designation of "streamer," a term that could only apply to a long, dangling aquatic.

When Gimingham and Birse discuss life forms of their bryophytes, they propose that certain forms relate to the environmental conditions. For example, Eurynchium riparioides (Ms) grows lowest on the rock (where it is most moist), has a closely appressed, prostrate shoot system, and is thus able to withstand the scouring effect of rushing water while the moss is submersed during most of the year; a smooth mat offers the least resistance to water and is correlated with plants, such as E. riparioides, which adhere most strongly. Further support of this idea is evidenced by Jovet's (1932) work, where he found E. riparioides to be rheophilic, occurring in rapid chutes, especially the spillways of ponds, while he termed Brachythecium rivulare partially rheophilic, replacing E. riparioides in the dripping, but not torrential, part of a waterfall. However, Jovet (1932) and Watson (1919) both point out the ubiquitous nature of E. riparioides by its occurrence in very slow as well as very fast waters.

The ecological amplitude of such bryophytes as Eurynchium lends criticism to schemes like that of Lorentz or Gams (in Verdoorn, 1932), who classify by habitat. Lorentz divides his Aquaticae into: Paludosae (marshy), Fontanae (flowing water), Irroratae (moist areas--the dew plants), Natantes (floating and submerged), and Fluctuantes

(floating). Thus, Eurynchium would fall in several of these: Paludosae, Fontanae, Fluctuantes, and possibly Irroratae.

Gams (1932) uses Nereidia for constantly submerged and Amphinereidia for amphibious forms. By his system, the Nereidia would encompass the Fontinalaceae and the Hygrohypnion federation: Hygrohypnum spp., Eurynchium riparioides, and maritime species of Sciaromium. Meanwhile, Hygrohypnum palustre is Amphinereidic. Gams, in 1953, warns of the use of only a generic designation for a federation "Les noms des unions, federations, etc., deraient être choisis de façon à exclure toute confusions. Des designations trop abregies sont à eviter, p. ex...Rhynchostegion (pour Rhynchostegietum riparioides = Platyhypnetum rusciformis, non pas Rhynchostegietum muralis)..." Because Rhynchostegium riparioides is treated in this paper as Eurynchium riparioides, I would further prefer not to use generic names alone until our system of classification is more stable. Thus, instead of a genus, Gams discusses the Hydro-Martinellion by designating the Scapanietum undulatae formation by species, as I have done in this paper.

Fontinalis dalecarlica Streams (Fontinaletum dalecarlicae)

Fontinalis dalecarlica, the most nearly ubiquitous of the bryophytes, occurs in first, second, and third order streams, in 0-3 foot streams to the widest included in the study (40-60 feet wide), in depths of about 5 inches to depths of 2-3 feet, in shaded or sunny areas, in rapids and falls or in pools. And the Fontinalis dominant streams are the second greatest in number, comprising five of the 28 streams; in addition to these there are several Scapania dominant

streams in which dense Fontinalis beds occur. However, the latter will all be treated as Scapania streams.

Due to the ubiquitous nature of F. dalecarlica, it is impossible to characterize its stream type. Rather, we can state that these are streams with large, flowing mats of "streamers." Perhaps the only characterization one can suggest is the ability of Fontinalis to occupy the larger, deeper streams, such as Mud Run and Muddy Creek, where the other bryophytes occur only on the edge or near the water-air interface on emergent rocks. Moreover, it does not occur in the narrow, shallow streams where it would surely be out of water part of the year. Studies by Irmscher (1912) show that other species of Fontinalis (F. antipyretica and F. squamosa) die after one week of air drying.

With its long, dangling branches, F. dalecarlica gives more the appearance of higher plants than any other bryophyte studied. Because its mat is loose and flexible, large insects may occur here, although they never occur in mats of other bryophytes of the same stream. For example, only in Fontinalis could I find third year Pteronarcys naiads --the one-inch long stonefly. But the large plant affords less protection from the current because turbulence produces a whipping motion of the plants, preventing the existence within the bryophyte stand of a water mass that is unaffected by stream turbulence. It also suggests less protection from predators, assuming that these larger animals can get into the depths of a Fontinalis clump more easily than into the closely-meshed mats of other bryophytes.

Fontinalis often harbors a diverse insect fauna, but in other collections may have very few individuals and species. It appears

to provide a satisfactory home for Chironomidae, where these tiny midges often nestle in the axil between the stem and leaf or attach a tubular sand case to the stem or leaf backs. Like the chironomids, simuliid larvae such as the Simulium tuberosum complex attach themselves in leaf axils with only their heads visible. It is possible that these positions provide safety from drifting while enabling the algal-feeding Simulium (Cummins, pers. comm.) to catch what passes by. Frequently the branching respiratory filaments of simuliid pupae (Prosimulium hirtipes complex) extend from the axial net cases (Plate 7), or at other times the larvae have used a leaf with a thin net to make the pupal case, replacing the usual stiff case used on the stems of these plants. In streams like Toliver and Pohopoco, the caddis Diplectrona modesta extends nets from branch to branch, catching the passing detritus and plankton, while the larva reposes in a net and sand case near the base of the plant. Apparently the most likely moss for finding micro-caddis (Hydroptilidae), Fontinalis frequently is decorated with the attached cases of Hydroptila and Oxyethira (Plate 7), while a brachycentrid larva (new genus) not only attaches the anterior end of its case to the plant, but also uses Fontinalis leaves, with other bryophyte leaves, in case building (Plate 7).

#### Muddy Creek

Plate 10, Fig. 1. adapted from USGS Sang Run quadrangle

\*Garrett Co., Md.: Swallow Falls State Park, above falls  
#(1965:5-4, 7-9, 8-25, 12-25; 1966:3-22, 6-11)

Muddy Creek is one of several Youghiogheny tributaries studied. The others are Neds Run, Piney Creek, Ginseng Run, Hoyes Run, Toliver

\*Location of stream

\*(year:month-day)

PLATE 7. FONTINALIS DALECARLICA WITH ATTACHED INSECTS

1. Brachycentrid genus 1 (new genus)
2. Prosimulium hirtipes group, pupa
3. Oxyethira case
4. Hydroptila case



Run, and Deep Creek tributary. Among all the streams studied, the Youghiogheny tributaries flow through the area with the most snowfall and the coldest, wettest weather in Maryland, where temperatures seldom rise above freezing from December to February (Dept. Geol., Mines, & Water Res., 1954). These extremes contribute to a unique segment of Maryland flora in which northern hardwoods contrast with white pines and hemlock stands. Garrett County is a rolling plateau interrupted by deeply cut stream valleys and northeastwardly oriented ridges which parallel the northeastward trend of the anticlines and synclines. The northward flowing Youghiogheny and Casselman Rivers drain the Ohio River basin in the county, while the Savage River flows south to the Potomac River. Contributing to local topography are tributaries which gouge out east-west oriented gaps in the ridges. It is these tributaries, located in elevations of 2200 feet to 2600 feet, bounding over boulders or sliding over shales, which provide the year-round collections of this study.

As the name implies, the headwater region of Muddy Creek is "muddy" in color, but it is clear at the collection site. Originating in Cranesville Pine Swamp, Muddy Creek flows over Pocono, Greenbrier, and Mauch Chunk shales before reaching the Pottsville conglomerate of the main collection site. At the collection site in the 100 feet above the falls, Muddy Creek is the widest stream studied. Like Mud Run (also a Fontinalis stream), it is in open sun and is bordered by rhododendron and virgin hemlock forest. In this area, the raging torrents of snowmelt waters slow to peaceful moderation in summer, passing over solid bedrock before plunging over thirty-foot falls in Swallow Falls Park. It is in this 100 feet above the falls that

Fontinalis dalecarlica forms large, streaming clumps. Although located on the bedrock just above the falls, Fontinalis occurs on the sides of submersed boulders less than 100 feet farther upstream. No other bryophyte could be found in the collecting area above the falls except during high water periods. But on August 25, 1965, the water had receded sufficiently to collect Hygrohypnum luridum from the falls.

Below the falls .4 miles, Muddy Creek joins the Youghiogheny River. This lower, sunny and deeper section of the stream is depauperate of bryophytes, but one boulder supported Fontinalis and Sciaronium lescurii at about 100 feet above the river junction.

#### Neds Run

Plate 10, Fig. 1. adapted from USGS Sang Run quadrangle

Garrett Co., Md.: east of Cranesville Pine Swamp by culvert (1965:5-4)

Neds Run drains the western side of Piney Mountain to join Muddy Creek in Cranesville Swamp. At its source it drains the soft Mauch Chunk shales, but it crosses the Greenbrier limestone at the collection site .6 miles below. Since it is narrow and flows through tall, mixed hardwood forest, where its borders are lined with Caltha palustris L., little direct sunlight reaches its surface. Although this stream exhibits primarily sandy bottom, a few small boulders occur near its mouth, and here streamers of Fontinalis dalecarlica undulate in the moderately flowing water.

#### Mud Run

Plate 8, Fig. 1. adapted from USGS Stoddardsville quadrangle

Carbon Co., Pa.; Hickory Run State Park, downstream from bridge, Pa. 903 (1965:7-29)

Mud Run finds its origin in Pimple Hill of the northern Pocono Mountains and gathers waters from such first order tributaries as Swamp Run, Laurel Run, and Hoch Run, all of which drain Lake Mountain on the western side of the Pocono Mountains. Flowing westward, Mud Run reaches the Lehigh River, then the Delaware to the Atlantic. Shaded by a forest of northern hardwoods and hemlocks with a rhododendron understory, these streams all flow over Mississippian Pocono sandstones and exhibit rocky bottoms at their collection sites. However, the physical appearance of the tributaries is quite different from that of Mud Run.

In general, the forest-shaded Mud Run drains the same soils as Swamp Run, but from the source to the collection site, it traverses only Pocono sandstones. Mud Run is one of the largest streams studied. Because of its width, full sunlight reaches much of the stream surface during part of the day. Perhaps due to its combination of greater depth, clear, cool water, and sunlight, the stream has the most lush growth of Fontinalis of any stream in the study. Here, the moderately fast waters flow over the Fontinalis-covered rocky bottom while emergent boulders frequently support growths of Scapania undulata just beneath the water surface.

#### Swamp Run, a Mud Run tributary

Plate 8, Fig. 1. adapted from USGS Stoddardsville quadrangle

Carbon Co., Pa.: Hickory Run State Park, south of Pa. 534  
(1965:7-29)

Through its upper reaches on Lake Mountain, Swamp Run drains peat and muck of the Klinesville soils, while near the collection area its moderately flowing waters erode Papakating silty clay loam, a wet, poorly drained soil with mucky surface formed under hemlock, spruce,

rhododendron, and Sphagnum (Carbon Co. Soil Survey, 1962). In a sunny stretch streaming Glyceria fluitans (L.) R. Br. nearly chokes the stream above the collection site, but at the edge of a shaded, swampy section, bordered with Veratrum viride Ait., bryophytes are the only vegetation. Whereas Fontinalis occurs on the bottom rocks and in swirling waters of rapid gradient changes, leafy liverworts occur on submersed edges of emergent rocks. Because of the preponderance of the liverwort Scapania undulata in Hoch Run and Laurel Run, these streams are treated with the Scapania group. But Swamp Run, where Fontinalis dalecarlica spots the rocky bottom, has only sparse growths of the leafy liverworts Plagiochila? and Frullania sp., while the thallose liverwort Riccardia cf. sinuata is an occasional constituent. Accompanying this unusual combination of liverworts is the aquatic lichen Hydrothyria venosa Russell, while Fissidens bryoides nestles among the bases. Apparently because the stream is rugged, moderately fast, and narrow, its heavy load of ice, water, or eroded materials causes Fontinalis to lose its leaves.

#### Pohopoco Creek tributary

Plate 8, Fig. 3. adapted from USGS Windgap quadrangle

Monroe Co., Pa.: parallels west of Pa. 115, 2 mi. north of Effort (1965):7-29)

Pohopoco Creek drains the red sandstones of the Catskill formation in the southern Pocono Mountains through the stream's multiple sources before joining the waters of Mud Run in the Lehigh River. Shaded by northern hardwoods and rhododendrons, the stream slides around emergent boulders with their clumps of Sciaromium lescurii and their trailing Fontinalis in slow waters, while occasional polsters

of Eurynchium riparioides occur in the rapids on small rocks. Nestled at the bases of these bryophytes are tiny plants of Fissidens bryoides. Evidencing a rough life, the Fontinalis here is stripped of most of its leaves and displays several old capsules. Watson (1963) states that capsules of F. antipyretica may be found more often on plants exposed to air in dry weather. However, Elssmann (1923) states that plants kept in the laboratory produced capsules without being out of the water in whole or in part. He could not say if the same is true in nature.

Hygroamblystegium fluviatile Streams

(Hygroamblystegietum fluviatilae)

By far the most frequent species studied, H. fluviatile appears to avoid segregation. Because of its habit of occurring in streams with other bryophytes on the same or different rocks, it can be considered as the dominant indicator of a group which includes one or more other species: Eurynchium riparioides, Hygroamblystegium tenax, Amblystegium varium, Brachythecium plumosum, Brachythecium rivulare, and less commonly Grimmia alpicola var. rivularis and Leskea cf. gracilescens. In addition to these, the ubiquitous Fontinalis dalecarlica frequently appears. If the latter is dominant, the stream is treated as a Fontinalis stream. When Scapania undulata appears in small quantities in these streams, the categorization is more difficult. While the Hygroamblystegium group frequently has a fauna similar to that of Fontinalis in the same stream, Scapania undulata has the most unique fauna of the major bryophytes studied. Consequently, streams containing both Scapania and Hygroamblystegium will be discussed here

if the latter is dominant, but of necessity will again be mentioned in the Scapania group. In his study of Brachythecium plumosum, Gaume (1928) mentions that B. plumosum is characteristic of the Rhacomitrium aciculare and Scapania undulata group. But this is not true of the streams in this study.

While Hygroamblystegium fluviatile and its group members (not Fontinalis and Scapania) do not all look the same, they form similar relatively dense mats on rocks. Apparently their habitat requirements are about the same, as evidenced by their frequent coöccurrence in the same mat. So it can be expected that their insect fauna may be similar unless the particular species of bryophyte exerts an influence on the insects. The data indicate that this influence is not apparent; thus, grouping seems justifiable. Another justification for grouping is the extreme variability of several of the moss species so that their gametophyte characters overlap. For example, H. fluviatile, H. tenax, and Amblystegium varium are difficult to separate; Brachythecium plumosum, B. rivulare, and Eurynchium riparioides overlap.

If we consider all the streams treated here as Hygroamblystegium streams, we find that they are all narrow and shallow, usually less than eight feet wide and only inches deep (Table II). On the other hand, this does not imply that these bryophytes occur here exclusively. On the contrary, the 60-foot wide downstream area of Muddy Creek has H. fluviatile, but not as a dominant. Rather, it occurs in the larger streams at the water surface on boulders. Thus all of the occurrences noted are at the water-air interface. Furthermore, any attempt to correlate these bryophytes with stream order proves futile because they occur in first, second, and third order streams. However, this

compares with the observation of Harrel (1966) whose third order stream was more similar to the sixth order stream than another of the third order. In the present study, it appears that the Hygroamblystegium group occupies first and second order streams and those third order ones which have areas similar to the lower orders.

While comments on H. fluviatile hold true for stream type of the other mosses of this association, further comment is needed on specific occupance of the streams. For instance, H. fluviatile and Grimmia alpicola var. rivularis were not found on vertical rocks of waterfalls, while Brachythecium plumosum and B. rivulare, along with their counterpart, Eurynchium riparioides, were in rapid falls or on midstream rocks, as already reported in 1919 by Watson. In both of these habitats one might find the lichen Dermatocarpon aquaticum (Weis.) Zahlbr. intermingled with the mosses.

Throughout the year one can find clumps of stems with naked costae due to the scouring of H. fluviatile, while E. riparioides shows the effects by fraying. It is usual to find the lower leaves torn away on these aquatic bryophytes (Watson, 1919).

Among the branches and leaves of Hygroamblystegium and its consorts, the tiny chironomid larvae may hide, but are less frequent in the leaf axils than in those of Fontinalis, probably because the leaves are smaller and do not hide the larvae as well. Even more rarely, a larva incorporates a Hygroamblystegium leaf into a loose case. Occasionally one can find a branch of the moss attached to the vegetable case of the caddis Micrasema (Brachycentridae), while the tiniest of these larvae attach sand cases weakly to the leaves and stems. Older larvae, prepupae, and pupae frequently attach the front, back, or both ends of the case to the moss. Another brachycentrid (new genus) occurs among



H. fluviatile and Eurynchium riparioides mats, utilizing these materials for its case. These cases are especially interesting because the larva may incorporate only the costae of Hygroamblystegium fluviatile, leaving dangling ends of costae, or it may make a smooth case with the lamina of the leaf included.

#### Sideling Hill Creek tributary

Plate 10, Fig. 4. adapted from Map of Allegany Co., Md. G. S. 1905

Allegany Co., Md.: parallel to U. S. 40, .6 mi. west of Sideling Hill Creek  
(1965:3-29)

While its own tributaries exhibit rapid drops, this third order tributary is nearly level and only moderately fast as it courses along the eastern side of the scrub pine-hardwood Town Hill Mountain. Whereas it originates in Hampshire shales, it traverses Jennings shales through open sun before it enters Sideling Hill Creek to be carried to the Potomac River. In the collection area it cuts a shallow channel over a bottom of sand, pebbles, and soil. Along the banks, rocks covered with Brachythecium plumosum are submerged by high waters of spring. The paucity of insects in these spring collections is probably due to the temporary nature of the habitat.

#### Sinking Creek

Plate 12, Fig. 2. adapted from A. S. Caster. 1958. Mt. Lake Biol. Station & Vicinity

Craig Co., Va.: Newport Recreation Center, Newport.  
(1965:3-18)

With tributaries arising at elevations of 24-2500 feet in Cooper Ridge Dolomite limestone springs on the northern side of Sinking Creek Mountain, Sinking Creek itself meanders through the valley below and finally enters the New River, which empties into the Ohio by way of

the Kanawha River. Its bottom rocks are often carpeted with thin mats of Amblystegium varium, Hygroamblystegium fluviatile, and Brachythecium plumosum, but more commonly with Hygroamblystegium tenax. Along the banks Conocephalum conicum, growing on tree roots, finds itself in the high springtime waters. According to Gimingham and Birse, 1957, Conocephalum conicum will succumb in moisture; it also adheres weakly and would probably be eroded by running water. But this thallose mat was entangled by roots of grasses and other vascular plants, so it appeared relatively safe from erosion.

Mountain Lake tributary to Sinking Creek

Plate 12, Fig. 3. adapted from A. S. Caster. 1958. Mt. Lake Biol. Station & Vicinity

Giles Co., Va.: north and west of road to Mountain Lake on Salt Pond Mountain, east of U. S. 460  
(1965:3-18)

This first order Mountain Lake Park tributary, one of the smallest streams studied, is intermittent in its upper reaches of Salt Pond Mountain (Caster, 1958). In March it trickled through the collecting site, where moss-covered rocks were wet primarily because of spray as the water coursed the rugged channel. On the north it is shaded by a mixed hardwood forest, but it embraces the afternoon sun from the south where the road to the biological station replaces the trees. On the rocks in the splash and submersed are mats of Brachythecium rivulare, Hygroamblystegium fluviatile, and H. fluviatile var. orthocladon. However, attesting to the temporary nature of the stream, the insects are few, consisting primarily of Diptera, especially chironomids and Pericoma (Psychodidae) larvae.

Rock Castle Creek

Plate 12, Fig. 1. adapted from USGS Floyd quadrangle

Patrick Co., Va.: Va. 710, 1st bridge, 2 mi. north of 40N; Woolwine (1965:7-21)

Rock Castle Creek originates in southern Sugarloaf and Rocky Knob Mountain, coursing through a mixed hardwood forest to eventually reach the Sycamore River. From there this third order stream travels Smith River, Dans River, Jackson River, and Pee Dee River before entering the Atlantic at Winyan Bay. In the collection area, most of the slippery, black boulders are carpeted with the riverweed Podostemum ceratophyllum Michx. However, a mat of Eurynchium riparioides covers rocks in the shallow water of rapids.

Johns Creek tributary

Plate 12, Fig. 5. adapted from A. S. Caster. 1958. Mt. Lake Biol. Station & Vicinity

Craig Co., Va.: just before Giles Co. on rt. 632 (1965:7-14)

This first order tributary originates in Giles County and flows northeastward to Craig Creek, draining the north side of Johns Creek Mountain, and finally reaches the Chesapeake Bay through the James River system. In a series of step falls, where the stream bounds over limestone rock (Woodson, 1957), dense mats of Hygroamblystegium fluviatile grow. Only on some of the larger submersed boulders can one find the streamers of Fontinalis dalecarlica.

Goose Creek

Plate 12, Fig. 4. adapted from USGS Elliston quadrangle

Floyd Co., Va.: near end of road south of Piedmont (1965:3-22)

The third order Goose Creek cuts through the Blue Ridge Mountain, leaving large boulders in the stream bed before emptying into the Roanoke River. This hemlock-hardwood shaded stream shears across the thin mats of Hygroamblystegium fluviatile which cling to the midstream boulders, while other plants dangle into the water from the stream-bank. While H. fluviatile occurs both on the edge and in the middle, Eurynchium riparioides, Brachythecium rivulare, and Brachythecium plumosum occur in only one collection each out of 13.

Hoyes Run and Ginseng Run (Sang Run)

Plate 10, Fig. 1. adapted from USGS Sang Run quadrangle

Garrett Co., Md.: Hoyes--east of Hoyes Run (town); Ginseng--east of Sang Run (town), 4.6 mi. west of 219 at McHenry; and near rt. 21 junct.  
(Hoyes, 1965:8-25; 1966:3-22, 6-11; Ginseng, 1965:5-4, 7-9)

Because of their proximity and similarity, the second order Hoyes Run and Ginseng Run (Sang Run) warrant simultaneous consideration. Both meander in and out of mixed hardwood forests and pastures; both have moderately fast flow; both are narrow and shallow in the collection area. Whereas both their collection sites are located at 2040 feet, Hoyes Run drains northern Marsh Hill, while Ginseng Run drains southern Ginseng Hill. Although their mouths to the Youghiogheny River are only 2.5 miles apart, Hoyes Run empties across Mauch Chunk shales while Ginseng finishes in Greenbrier limestone. Furthermore, Hoyes originates in Pocono sandstone while Ginseng originates in the Catskill formation, but, at the upstream collection site, Ginseng Run crosses the Pocono sandstones.

At its collecting site less than a mile from the mouth, a shoulder of shale provides the substratum for Ginseng Run bryophytes, where Hygroamblystegium fluviatile and Eurynchium riparioides grow intermin-

gled. On one mud-covered rock a few branches of Thuidium delicatulum and Scapania undulata were mixed with these. In the open water, branches of Fontinalis dalecarlica extend from the submersed rocks. During July, one can find vigorous growths of Fissidens bryoides at the bases of the other bryophytes. This usually minute moss aroused the curiosity of Dr. R. A. Pursell (pers. comm.) because of its large, robust form.

At the upstream site of Ginseng, only Eurynchium riparioides and Hygroamblystegium fluviatile were collected, but no collections were taken here in July when the other bryophytes were found down stream.

Unfortunately, the Ginseng Run collection dates did not coincide with those of Hoyes Run. On three dates of sampling, Hoyes Run displayed only Hygroamblystegium fluviatile and Eurynchium riparioides growing in large dense carpets on the submersed sloping bedrock, with a tiny Fissidens, possibly F. pusillus, occurring rarely among their bases.

#### Piney Creek tributary

Plate 10, Fig. 2. adapted from USGS Frostburg and Avilton quadrangles Garrett Co., Md.: tributary entering south side of Frostburg reservoir, 100 feet from reservoir by bridge of dirt road; reached from U. S. 40 (1965:5-5)

This first order tributary is located in the northeastern part of Garrett County and flows northward into the Frostburg Reservoir and finally to the Youghiogheny River through Casselman River in Pennsylvania. It originates in Hampshire rock, and flows over Jennings shales and sandstone in the collecting area, where its slow-moving waters result in a heavy deposit of sand and mud on the few bryophytes: Hygroamblystegium fluviatile, Eurynchium riparioides, and Fontinalis

dalecarlica, with Fissidens bryoides at its base.

Deep Creek tributary

Plate 10, Fig. 1. adapted from USGS Garrett Co. Atlas

Garrett Co., Md.: south of Swallow Falls Road by private mailbox  
356, just above Deep Creek Lake  
(1965:5-4; 1966:3-22, 6-11)

This first order tributary soon dumps into the man-made Deep Creek Lake that empties into Deep Creek, which finally joins the waters of the other Garrett County streams in the Youghiogheny River. My observations of the stream in 1965 indicate that it is intermittent at the collection site in dry years. Its moderate to rapid flow in early May gave way to a highly vegetated alley with an irregular trickle and small pools during the summer dry period. In March, 1966, it was again active. Characterized by large boulders, the stream stumbles through numerous riffles, rapids, and waterfalls in the less than thirty-foot long collection area. This portion of the stream is rapid and clear in March, probably swollen due to snowmelt runoff. Although situated at the collection site on soft, nearly neutral Mauch Chunk shales, and draining primarily the Greenbrier limestone formation in its upper reaches, this tributary is shaded by the acidophilous rhododendron and a hemlock-hardwood forest. Carpeting its banks and emergent rocks are numerous species of bryophytes. Whereas streamers of Fontinalis dalecarlica extend from the edges of submersed rocks, Scapania undulata, Eurynchium riparioides, Hygrohypnum luridum, and Hygroamblystegium fluviatile form clumps or polsters on basketball-sized rocks, especially where these rocks cause a change in the stream level. At the base of any of the mosses, one can find the tiny Fissidens bryoides. In March still other bryophytes can be found on rocks in the

spray caused by small waterfalls. Because of such a variety of bryophytes, this stream best fits with the Hygroamblystegium fluviatile group.

#### Gramlich Run tributary

Plate 10, Fig. 3. adapted from USGS Cumberland quadrangle

Allegany Co, Md.: parallels Gramlich Road, LaVale; east of U. S. 40 (1964:12-25; 1965:3-28, 5-3, 6-20, 7-10, 8-24, 12-24; 1966:3-23)

Possessing the third steepest elevation gradient of the 28 streams --400 feet per mile, the Gramlich tributary tumbles from its source in Piney Mountain over Pottsville conglomerate, Mauch Chunk, Greenbrier, Pocono, and Hamilton formations (Allegany Co. Atlas, 1900), before reaching the Jennings shales at the collecting site. Later it empties into Braddock Run, to Wills Creek, to the Potomac River.

Waterfalls, upturned shale ledges, small pools, and boulders provide a variety of possibilities for growth of bryophytes in this second order Gramlich Run tributary (so named in this study because it parallels Gramlich Road). This bubbling stream provided the only collection of Fontinalis flaccida, which came from a clump of leaf drift in a small pool, while streamers of F. dalecarlica extend from long, sloping submersed bedrock. In the 3-foot waterfall, Eurynchium riparioides, Brachythecium rivulare, and Brachythecium plumosum cling to the vertical rocks, while E. riparioides forms mounds at the base of the falls as well. In summer, the bryophytes are scoured away from the main channel of cascading water, but on each side of this channel a film of water streams down the rocks behind such mosses as E. riparioides and B. rivulare, keeping them constantly moist and influencing their insect fauna. Many of the same mosses also occur on the boulders and upturned shale ledges in the stream: B. rivulare, Grimmia alpicola

var. rivularis, Hygroamblystegium fluviatile, Brachythecium plumosum, and Eurynchium riparioides with Fissidens bryoides at its base.

Because the stream passes through a good timber stand of northern hardwoods, it may be influenced by tannic acids resulting from upstream logging. However, the logging road diverges from the tributary about a mile upstream, and all logging to date occurs above this point.

#### Little Bennett Creek

Plate 11, Fig. 2. adapted from USGS Damascus quadrangle

Montgomery Co., Md.: west of Oak Drive (old rt. 27), Damascus  
(1964:6-3; 1965:3-26, 6-29, 8-20)

This first order tributary cuts its way across the Ijamsville phyllite through a mixed hardwood scrub pine forest. Here, matted bryophytes carpet the irregular surfaces of the scattered milky quartz rocks. Like the streams near Watkins Road, this one displays such bryophytes as Hygroamblystegium fluviatile, Brachythecium rivulare, Sciaromium lescurii, and Thuidium delicatulum. The fern moss, Thuidium, is from intermittent waters of a spring side channel, while the others can be found in the main stream as well. Inversion of the rocks is suggested where these mosses occur on the undersides of the rocks in the swampy intermittent region.

Although this gurgling Piedmont stream was clear at the outset, a logging operation soon curtailed the study and at present a log road fords the stream in the collection area.

#### Seneca Creek tributaries

Plate 11, Fig. 1. adapted from USGS Gaithersburg quadrangle

Montgomery Co., Md.: south of Watkins Road (Md. 604), east of Md. 27;  
by residence of Burroughs and M. A. Bell  
(1965:3-27)

The smallest streams of the study are these two on the south side of Md. 604. Because they have no name, they shall be referred to as Burroughs and Bell, after the names of the nearest property owners.

The first order Burroughs stream flows through a cow pasture, thus being exposed to an obvious source of pollution. However, the water at the collection site is clear and is upstream from the fenced pasture area, so it is probably not polluted. While the owner reports that the stream always has water in it, this flow is not fast, even in spring. On the other hand, the Bell stream is definitely intermittent, as determined by Mrs. Ellis G. Glime and the Bell's (pers. comm.) in October, 1967. Originating just below Watkins Road, the stream barely moves to cross the nearly level open woods to the collecting site less than 100 feet from the road. Apparently this first order stream is the result of spring rain runoff and snowmelt.

Both streams traverse the Ijamsville phyllite formation under a canopy of mixed hardwoods. Their sandy bottoms have scattered rocks which support occasional small moss clumps including Hygroamblystegium fluviatile in the Burroughs stream and Bryhnia novae-angliae on wood in the Bell stream. The latter is included here for convenience as this is the only collection of this hydrophilic species and it is most similar to the Hygroamblystegium group. By the classification of Gimingham and Birse, 1957, it is a rough mat.

#### Elk Creek

Plate 8, Fig. 4. adapted from USGS Centre Hall quadrangle and Lesley, 1885. Centre Co.

Centre Co., Pa.: parallels Pa. 445 just north of Milheim (1965:7-28)

Elk Creek, a warm, sunny, moderately fast stream, cuts a channel varying in depth from inches in mossy areas to nearly two feet where large beds of Ranunculus longirostris Godr. grow. Its third order collection site is in an area of Hudson and Utica formation and gray Oneida conglomerate sandstone. Arising in Brush Valley slate and sandstone and draining Brush, Big, and Nittany Mountains, it courses to the Milheim Valley through an area of limestone. It may be the limestone which causes the cloudy appearance of the collecting site waters. On large, sloping boulders embracing the width of the stream, Hygroamblystegium fluviatile is entangled by filaments of green algae and nets made by Hydropsyche; Eurynchium riparioides appears occasionally.

#### Dingman's Creek

Plate 9. adapted from White. 1882. Pike & Monroe Co.

Monroe Co., Pa.: west of U. S. 209, near bridge (upstream)  
(1965:7-30)

Dingman's Creek passes from its source in Silver Lake over Hamilton sandstone, dropping over a series of waterfalls with their limestone coral, to cross a series of massive boulders at the collection site before joining the Delaware River about a mile below. At the partly shaded site, these boulders are suggestive of a tilted waterfall, creating a rapid drop. Consequently, the rushing waters bind the bryophytes to the rocks as one tries to lift them from the stream. The dark gray, flinty Marcellus limestone shales are extremely smooth and slippery when wet and make one wonder how such large masses of Eurynchium riparioides are affixed. Round pot holes in the rocks suggest the past fury of whirling pebbles which carved their basins. In a 2-3

foot deep pool, Fontinalis dalecarlica grows on the sandy bottom, while other submersed Fontinalis plants undulate from rocks in the rapids.

#### Saw Creek

Plate 9. adapted from White. 1882. Pike & Monroe Co.

Monroe Co., Pa.: west of U. S. 209, near concession stand for Winona  
Five Falls  
(1965:7-30)

At the collecting site, the moderately fast third order Saw Creek gives little suggestion of its numerous waterfalls upstream. Saw Creek drains the eastern half of Porter Township through Catskill, Chemung, and Genessee formations, dumping its waters into the Delaware River. Where Saw Creek passes the concession stand, this hemlock-hardwood shaded stream courses over sand and rocks overlying Hamilton shales. Here, a short first order tributary apparently arises from a spring to cut a 2-3 foot channel to Saw Creek. It is in this tributary that the unusual moss Fontinalis antipyretica var. gigantea occurs. With its large cup-shaped leaves, this variety provides a unique cover for midges to hide and reveal only their heads. Otherwise, the moss does not provide a protective mat, but rather a loose group of streamers suggestive of some of the vascular hydrophytes.

Also in the tributary are the vascular hydrophyte Elatine, rock-dwelling clumps of Aplozia riparia? (possibly a new record for Pennsylvania), and streamers of Fontinalis dalecarlica. However, in the main channel, the bryophyte mats consist of mostly Eurynchium riparioides, while Hygrohypnum ocraceum mats and Fontinalis dalecarlica streamers are rare.

Sciaromium lescurii Streams

Because of its occurrence in several Hygroamblystegium fluviatile streams, its similarity of growth form, and its somewhat similar insect grouping, this moss might best be considered with the H. fluviatile group. As already mentioned, it carpets rocks in the Little Bennett Creek tributary and accompanies Fontinalis on a downstream rock in Muddy Creek, but its occurrence in Pidcock Creek and the Toliver tributary as dominants are the only such cases in this study.

Except for a low species diversity, the Sciaromium lescurii insect communities are little different from those of the Hygroamblystegium fluviatile group, and their insects make about the same use of the moss. The most notable find is a blind specimen of the springtail Hydroisotoma schafferi in Little Bennett Creek. (Since the species diversity is so low, this moss is not included in the polygonal graphs.)

Pidcock Creek

Plate 8, Fig. 2. adapted from USGS Lambertville quadrangle

Bucks Co., Pa.: Bowmans Hill, west of Pa. 32  
(1965:7-4)

The first order Pidcock Creek meanders down the north side of Bowmans Hill, gathering its upstream waters intermittently in the Newark metamorphic rock. Before entering the Delaware River it passes the collection site where it crosses the Newark igneous and diabase rocks. Shaded by a mixed hardwood forest, the collection area courses slowly over sandy, pebbly bottom. On occasional small rocks one can find mats of silty Sciaromium, while Eurynchium riparioides is even less common. Occasionally Fissidens bryoides exists among the bases of these plants.

Toliver Run tributary (Tolliver)\*

Plate 10, Fig. 1. adapted from USGS Oakland quadrangle

Garrett Co., Md.: Swallow Falls Park, above road near entrance.  
(1965:5-4)

Near the collecting site in Toliver Run, this first order tributary contrasts with Toliver by dropping more than 140 feet per mile, but it passes here at a slower pace than downstream Toliver. Like Toliver, its fast headwaters drain from the Allegheny formation of eastern Snaggy Mountain to the rock of Pottsville conglomerate before the stream enters Toliver Run, which drops rapidly to the Youghiogheny River. Although it is narrow and shallow, it remains cool under a hemlock-rhododendron shade. Perhaps it is the size of the stream, perhaps it is the upstream substrata, perhaps it is only chance. But the silt-covered Sciaromium lescurii grows in this stream less than 100 feet from the mainstream, where it appears to be totally absent. In this more slowly moving stretch of the tributary, Sciaromium lescurii is a dominant, but it is not known why it appears to be absent from the portion of Toliver Run examined.

Fissidens bryoides

In general, the Fissidens of these Appalachian streams is F. bryoides. This is a species complex first described from a land plant and later subdivided into many varieties. It is distinguished on the basis of its marginal and costal cells and the number of laminate cells between the tip of the costa and the border. In this study, the specimens of Fissidens do not precisely fit the number of terminal lamina

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\*Toliver is the spelling found on USGS maps, but the sign in the park has Tolliver.

cells for F. bryoides, but approximate this species more closely than any other. Dr. R. A. Pursell (pers. comm.) is in agreement with the identification.

Any collections of F. bryoides were accidental. The moss is usually less than 1 cm. long and appeared in this study at the bases of other mosses. Because of its small size it was probably frequently overlooked. Since the scope of this study focuses upon insect communities in or upon bryophyte mats, such small growths would be unimportant because they are not dense and provide little more substratum than a bare rock. Consequently, the insect arrays would likely be similar to those on submersed rock.

#### Hygrohypnum

Hygrohypnum appears to be a relatively uncommon moss in the regions studied, but this may be due to the difficulty in collecting its habitat. For example, the occurrence of H. luridum in the falls of Muddy Creek has already been mentioned, wherein the plants could only be reached when the water receded during the summer drought. On the other hand, H. ocraceum occurs in Saw Creek on small rocks and riffles, but is still in rapid water. Like the Hygroamblystegium fluviatile group, Hygrohypnum forms a relatively dense mat and consequently provides only small internal spaces. This contrasts with the flowing strands of Fontinalis and the loose, spacious mats of Scapania.

On Hygrohypnum ocraceum mats in Saw Creek, the tiny, square cases of the new brachycentrid larva were attached, head upstream, to branches and leaves of the moss. In some instances the moss leaves were cut in linear pieces and cemented together to form part or all of the larval case. However, on Eurynchium riparioides in the same stream,

only the brachycentrids Micrasema (sp. 2) and Brachycentrus nr. numerosus appeared, without the new genus.

Limnophora larvae and pupae, almost exclusive inhabitants of Hygrohypnum luridum, frequent rapid water of falls where this moss is profuse, but the larvae occur among other mosses and other regions of the streams in lower numbers.

Scapania undulata Streams (Scapanietum undulatae)

One of the least common bryophytes studied, Scapania occurred only in six of the streams and dominated only three. Any generalization of its expected habitat from such meagre information is premature. Watson (1919) states that it seems purely a matter of chance whether Scapania undulata or Nardia compressa (Hook.) Grey is dominant on any given patch of rock when they occur together in a Pennine stream (England), while Gams (in Verdoorn, 1932) contends that it occurs in acid springs and brooks, often correlated with the Hygrohypnion federation. Where it occurred in these Appalachian streams, Fontinalis dalecarlica was always present in the same stream, but not always Hygrohypnum.

In this study Scapania is the only leafy liverwort dominant and is unique in having two rows of leaves folded so that a small lobe lies on top. This fold provides a shelter for small insects, while the nearly flat surface provides a substratum for the attachment of simuliid pupal cases.

Scapania provides case-building materials for several caddisflies. Older larvae of Lepidostoma incorporate portions of the leaf into their cases, along with flecks of bark and other vegetable matter. But it is the larva of the microcaddis Paleagapetus celsus which "prefers"

liverworts for its case. In 1962, Flint reported the first record of the larvae of this species, describing their liverwort case of Scapania nemorosa (L.) Dum. (normally a terrestrial species). The present study appears to be the first record of cases made of Scapania undulata and Plagiochila asplenioides? in several streams where S. nemorosa was unavailable. Other microcaddis such as Hydroptila and Oxyethira use the liverwort for attachment of larval, pre-pupal, and pupal cases. Even the free-living Hydropsyche (Hydropsychidae) uses Scapania leaves in his retreat near the base of the plant.

In May, numerous pupae of the Prosimulium hirtipes complex were attached to the curled tips of Scapania undulata, dotting both upper and lower surfaces with their thin net cocoons, while in June pupae of the Simulium tuberosum group had attached cellulose cases arranged with no apparent pattern. Even the chironomids made thin cases for their pupae to lodge between the upper and lower leaves, while one pupa occupied the empty Scapania case of Paleagapetus celsus. Larvae and eggs of these chironomid midges can be found between upper and lower leaves. Other Diptera, such as the tipulid Limonia sp., lay their eggs on the leaves, so that at times numerous larvae can be found there. But large larvae of Limonia are scarce, and it is likely that they move from this protected habitat to other parts of the stream. Meanwhile, the tipulid larva Dolichopeza americana, which is normally a terrestrial larva (Byers, pers. comm.), appeared in Scapania mats of Toliver Falls in December and March.

#### Toliver Run (Tolliver)

Plate 10, Fig. 1. adapted from USGS Oakland quadrangle

Garrett Co., Md.: Swallow Falls Park, west of Md. 219  
(1965:3-29, 5-4, 6-19, 7-9, 8-25, 12-25; 1966:3-22, 6-11)

Toliver Run begins its course in the Allegheny formation on the eastern slopes of Snaggy Mountain. Perhaps the most beautiful of the study streams, this hemlock-shaded Youghiogheny tributary courses over sloping Pottsville conglomerate, drops over step falls, and splashes into a pool as it plunges over a 4-foot drop in the collecting area. Here, Scapania undulata, with occasional Fissidens bryoides at its base, forms a solid mat across the sloping shales, crescents of the falls, and anywhere the water is very rapid. In slightly slower waters and pools, detritus-covered Fontinalis dalecarlica forms patches on the rocky surface, while the sandy bottom farther upstream (above the road) supports patches of Scapania. However, perhaps in response to changing water levels, the two bryophytes occasionally grow side by side in apparently the same amount of flow. One such case is where the two hang in the drip area of the 4-foot falls while the summer drought has directed the main flow to a low spot near the edge of the stream. This situation provides the data for comparison of physical features of Fontinalis and Scapania, as discussed later.

#### Laurel Run and Hoch Run

Plate 8, Fig. 1. adapted from USGS Stoddardsville quadrangle

Carbon Co., Pa.: Hickory Run State Park, above and below Pa. 503  
(1965:7-29)

As already discussed, these streams are of the Mud Run stream system and support growths of Fontinalis dalecarlica and Scapania undulata. Because of their floral and physical similarities, they should be considered together: both are shallow, sandy and rocky-bottomed first order tributaries. Laurel Run emerges from the densely shaded swamp hardwood forest to a sunny, willow-bordered area before again

## PLATE 8. PENNSYLVANIA STREAMS

## FIGS.

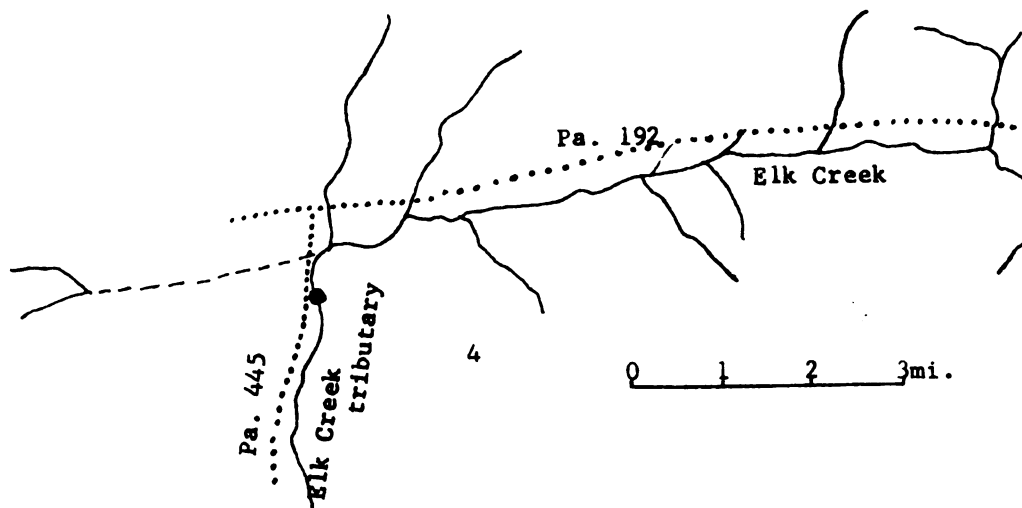
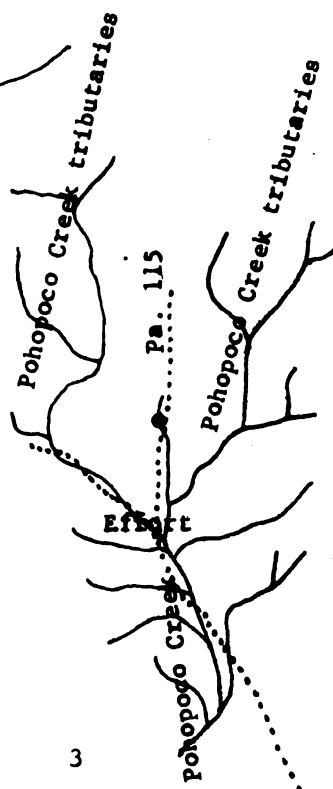
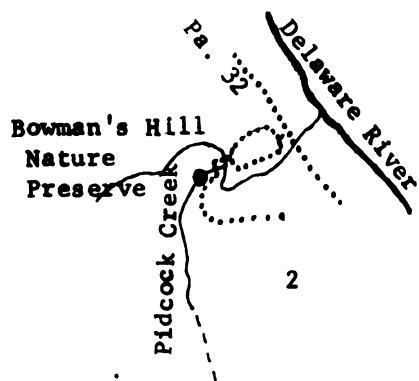
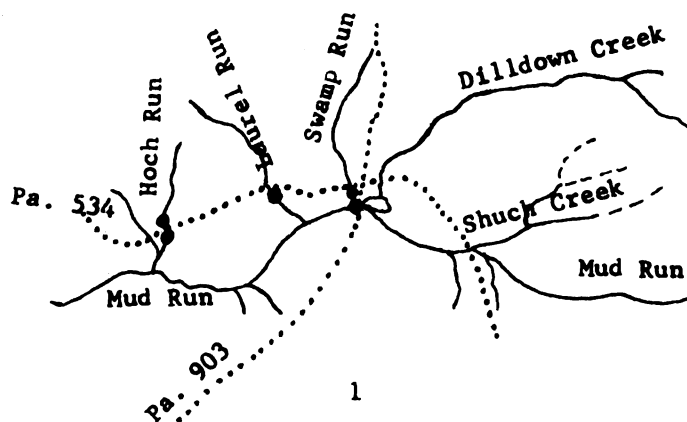
1. Mud Run System
2. Pidcock Creek
3. Pohopoco Creek
4. Elk Creek

..... Access road

— Stream channel

--- Intermittent stream

● Collection site



0 1 2 3 mi.

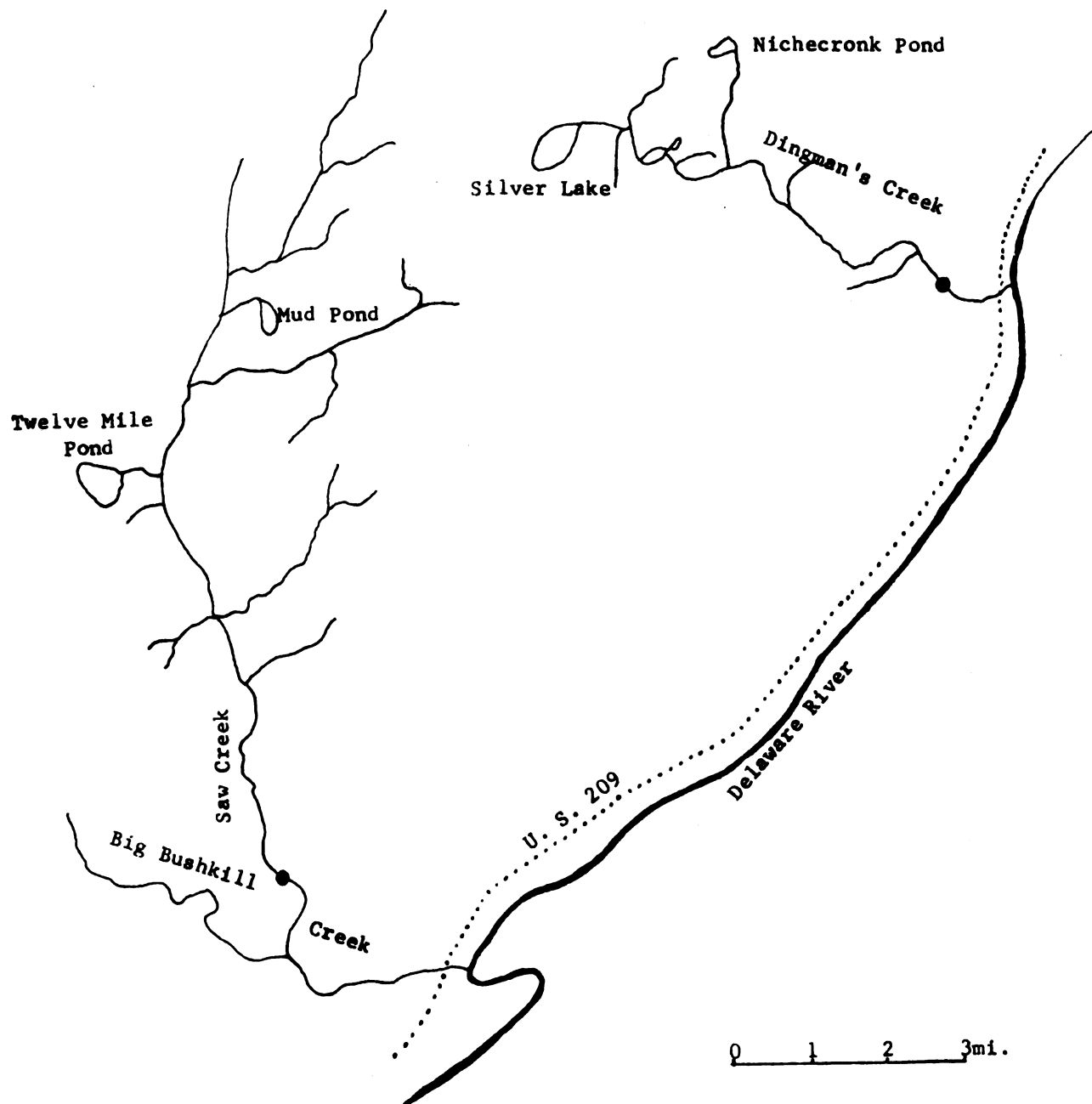
## PLATE 9. SAW CREEK AND DINGMAN'S CREEK

....Access road

~ Stream channel

- - - Intermittent stream

● Collection site



## PLATE 10. MARYLAND STREAMS: ALLEGANY AND GARRETT COUNTIES

## FIGS.

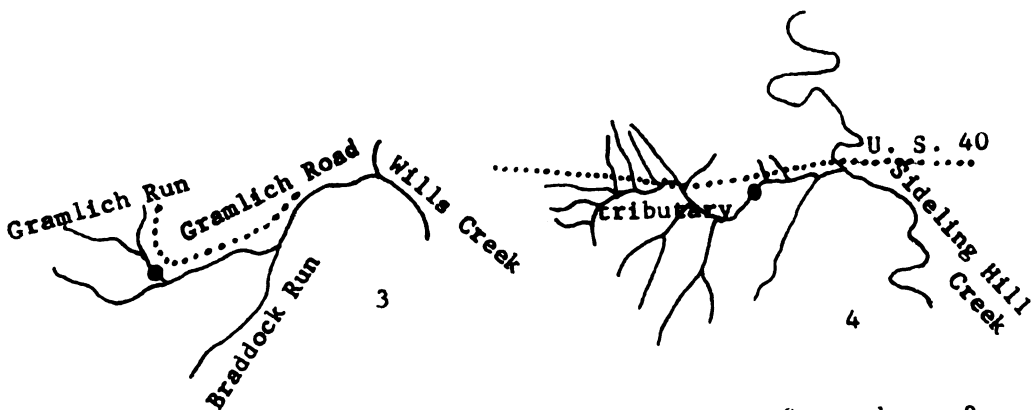
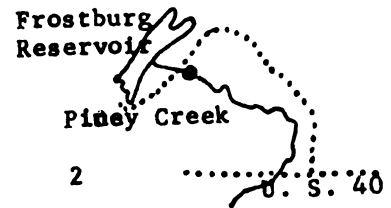
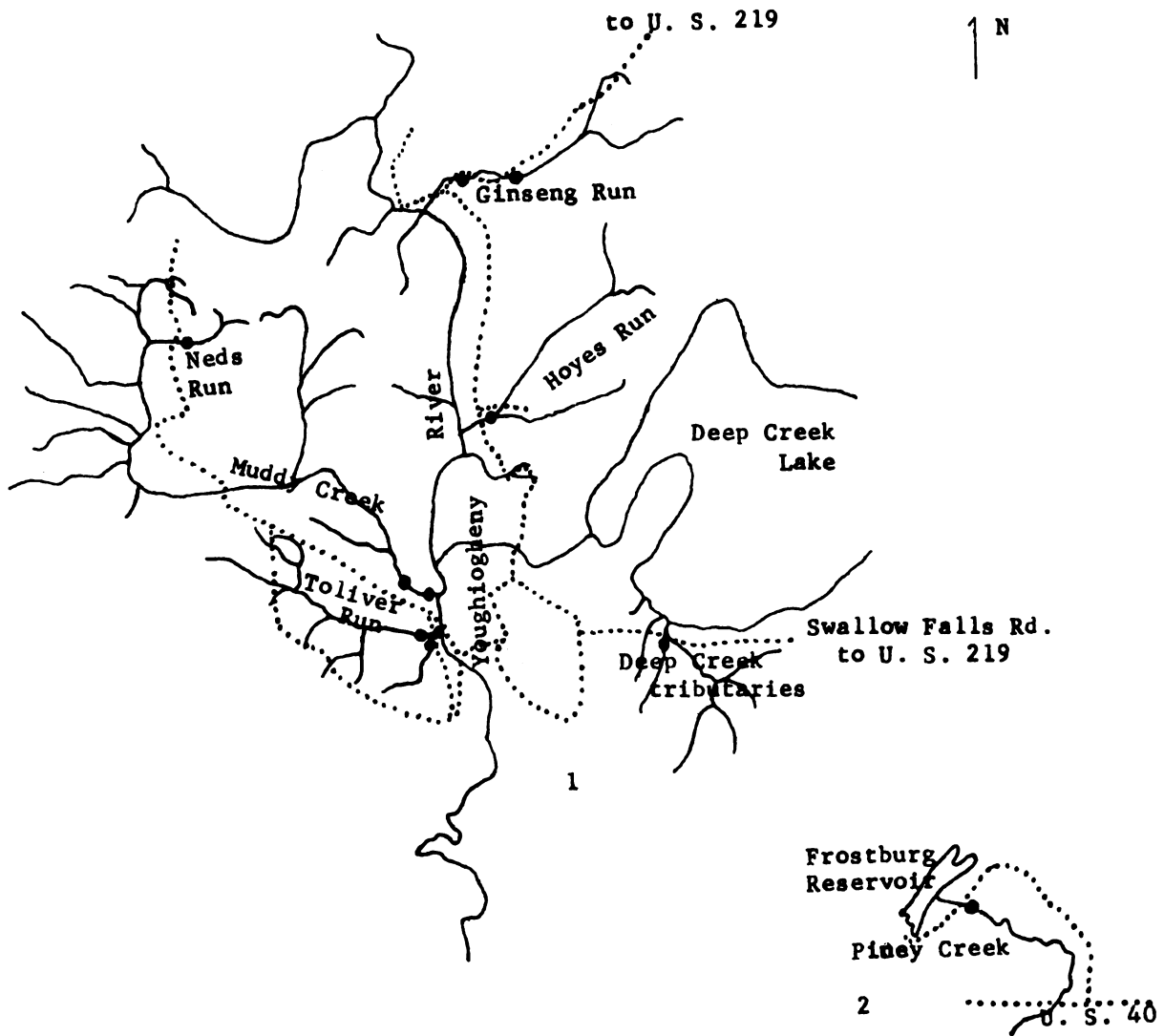
1. Youghiogheny River tributaries
2. Piney Creek
3. Gramlich Run
4. Sideling Hill Creek tributary

.....Access road

~~~~~Stream channel

---Intermittent stream

● Collection site



0 1 2 3mi.

## PLATE 11. MARYLAND STREAMS: MONTGOMERY COUNTY

## FIGS.

1. Seneca Creek tributaries
2. Little Bennett Creek

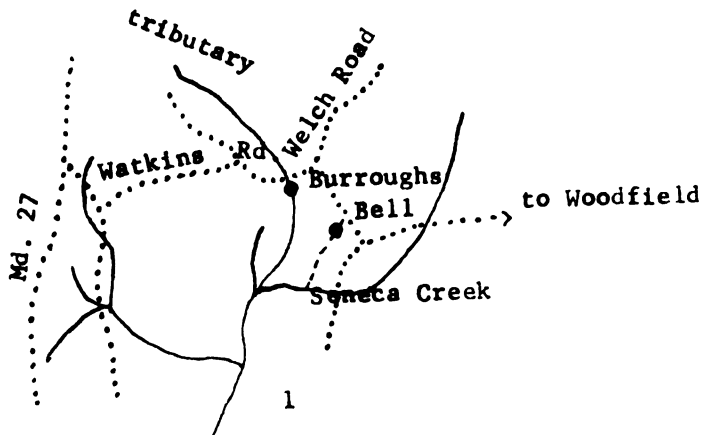
....Access road

— Stream channel

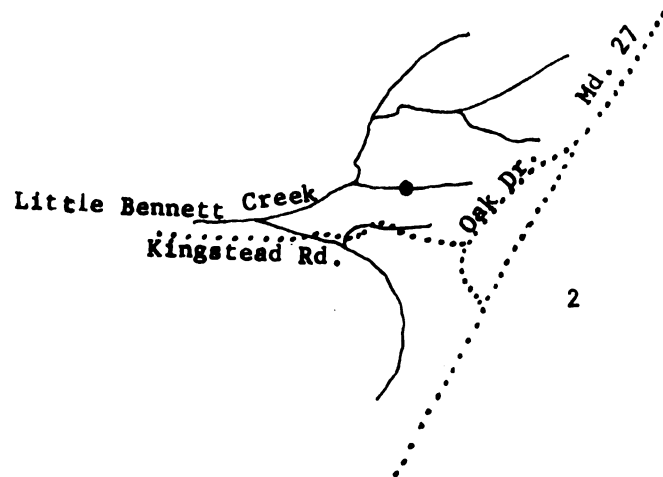
- - - Intermittent stream

• Collection site

1 N



Damascus



0 1 2 3mi.

## PLATE 12. VIRGINIA STREAMS

## FIGS.

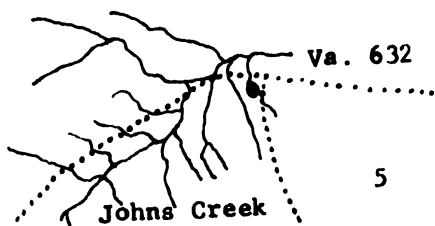
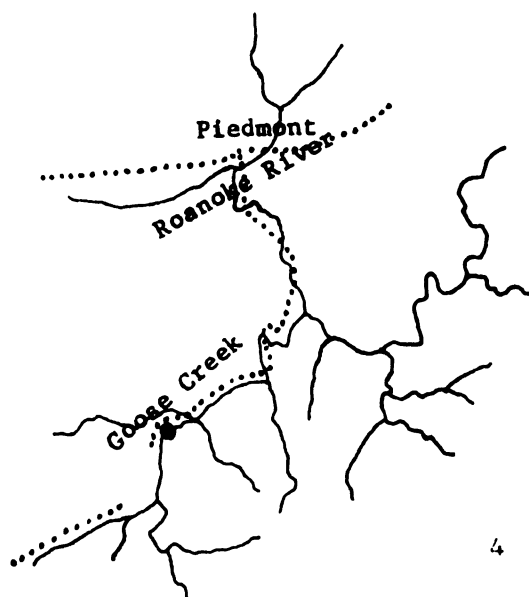
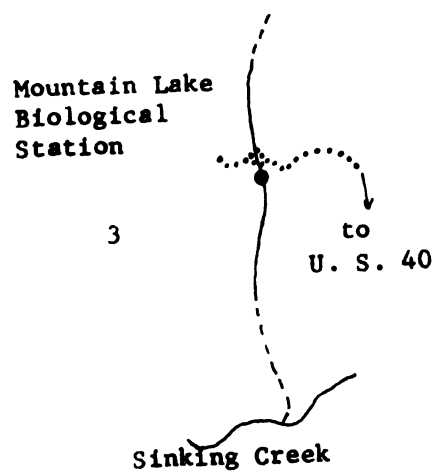
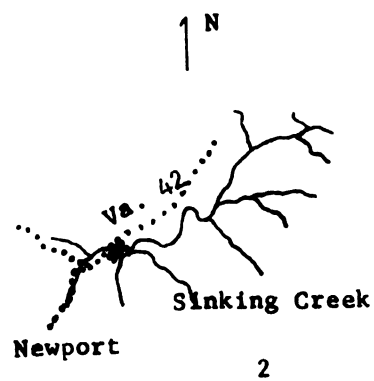
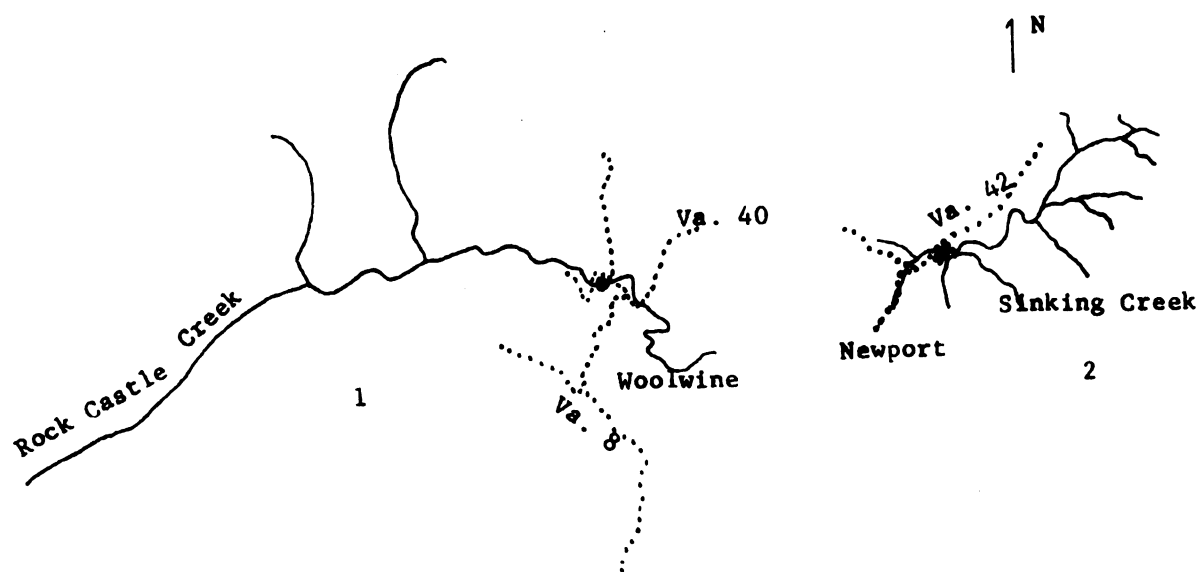
1. Rock Castle Creek
2. Sinking Creek
3. Mountain Lake tributary to Sinking Creek
4. Goose Creek
5. Johns Creek

.... Access road

— Stream channel

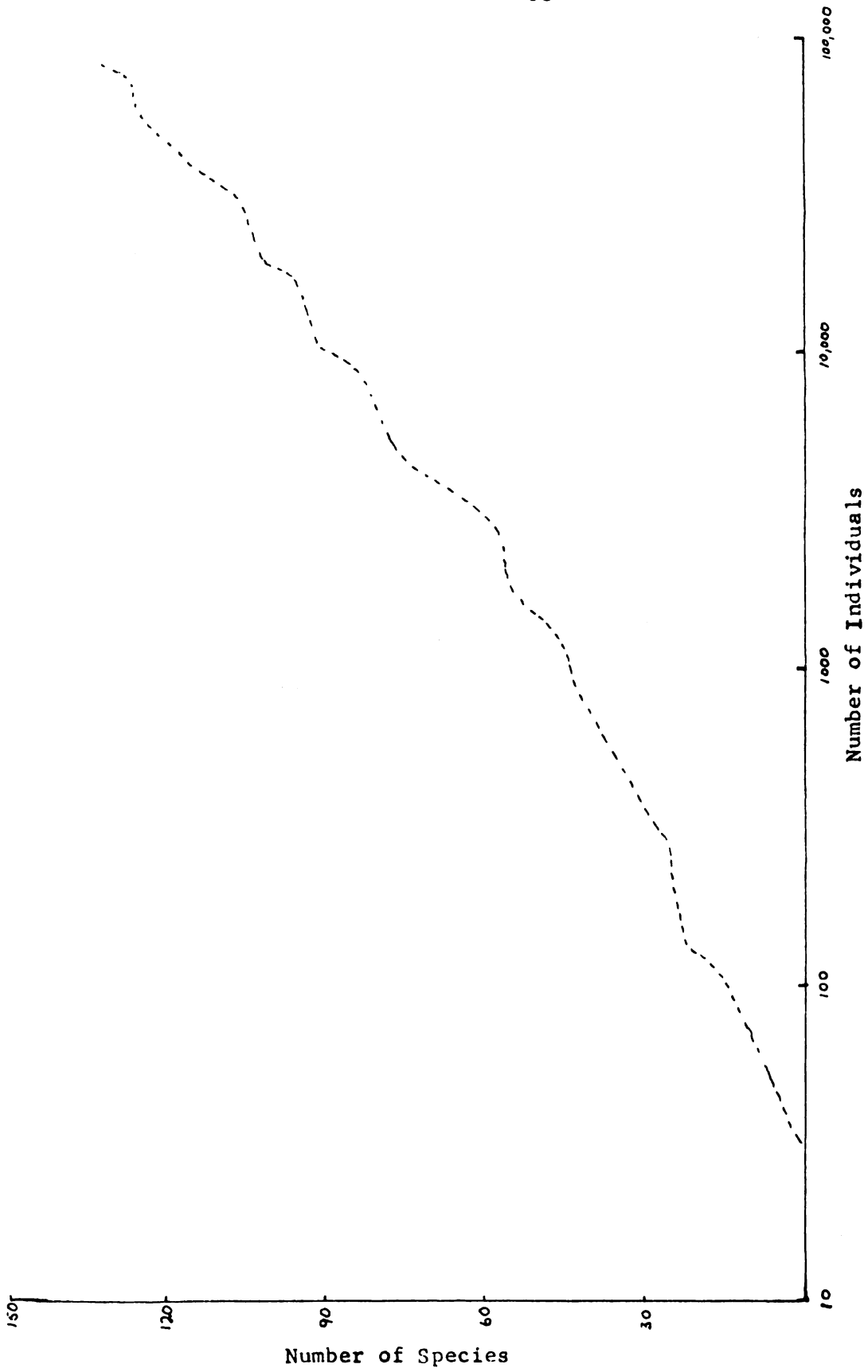
- - - Intermittent stream

• Collection site



0 1 2 3 4mi.

Figure 2. Increase in Number of Species with Addition of Individuals, Listed in the Order Collected.

**Figure 2.**

entering the woods around the collecting site. In this area, the sandy bottom is dotted with a few Scapania-covered rocks while Fontinalis extends from others. Meanwhile, Hoch Run emerges from a man-made wooden dam before converging into a narrow, rocky channel underlying a rhododendron thicket. On the logs of the dam and the wet rocks in the spray at the base, thick polsters of Scapania undulata grow, while the thicket shades rocks mantled with sand-filled Scapania mats and streamers of Fontinalis on the edges of rocks in riffles.

### Insect Communities

Richness, as used by McIntosh (1967), is a measure of the number of species present, while species diversity includes number of species and number of individuals. Although richness is inadequate for a modern balanced comparison of communities, it is both simple and useful. For such comparison of communities simple formulae are used, a common one being an adaptation of Sorensen's K (in Looman and Campbell, 1960), where  $K = \frac{2C}{A + B}$ , wherein A = total number of species in community 1, B = total number of species in community 2, C = number of species common to both 1 and 2. In this study, A and B represent numbers of insect species in two communities to be compared. These communities may occur in different bryophytes or in different streams. The highest coefficients indicate the most similarity, while the low ones indicate dissimilarity. Streams exhibiting very low coefficients with other streams frequently do so because the low-coefficient streams contain very few species of insects.

In Fig. 2 one can see the relationship between number of individuals of insects sampled and number of species added through chrono-

logical sampling. Except for a seasonal influx, the curve on a semi-log<sub>10</sub> scale approximates a straight line. From this, one could assume that the number of insect species to be found among these bryophyte species in the middle Appalachians would increase if more samples were taken, suggesting that the implications of community structure could change if more samples were taken. Inadequate knowledge of the number of aquatic insect species occurring in this region prevents us from making a reasonable estimate of the number of bryo-insects to expect.

#### Comparison of insect fauna of various aquatic bryophytes

Certain insects appear as obvious accidentals among the bryophytes (aphids, thrips), while others adapted for a different aquatic habitat are so infrequent as to be deemed accidental to the bryophytes (Blephariceridae, Epeorus). To eliminate the effects of these accidentals, only species appearing more frequently than a minimum number of times were considered: March, May, and June--more than 2 collections; summer--more than 4 collections. (The December collections were not compared in this way because they represented only two streams.) These arbitrary minimal values were selected because all of the eliminated insects were non-specific for a particular bryophyte species and were represented by one or few specimens in a collection. (The 4 summer collections of Paleagapetus celsus were considered because of their specificity for Scapania.) While the method is unprecedented, the results within this study are comparable with each other.

To obtain the community coefficients, the number of insect species was based on the total presence list for each bryophyte species. Tables III-VI give the bryophyte community coefficients, with the

TABLE III

## COMMUNITY COEFFICIENTS BY BRYOPHYTES, MARCH

|                              | <u>Font.</u> | <u>Scap.</u> | <u>Hygr.</u> |
|------------------------------|--------------|--------------|--------------|
| <u>Fontinalis</u>            | 1.00         |              |              |
| <u>Scapania</u>              | .80          | 1.00         |              |
| <u>Hygroamblystegium</u> gr. | .63          | .68          | 1.00         |

TABLE IV

## COMMUNITY COEFFICIENTS BY BRYOPHYTES, MAY

|                              | <u>Font.</u> | <u>Scap.</u> | <u>Hygr.</u> |
|------------------------------|--------------|--------------|--------------|
| <u>Fontinalis</u>            | 1.00         |              |              |
| <u>Scapania</u>              | .74          | 1.00         |              |
| <u>Hygroamblystegium</u> gr. | .90          | .73          | 1.00         |

TABLE V

## COMMUNITY COEFFICIENTS BY BRYOPHYTES, JUNE

|                              | <u>Font.</u> | <u>Scap.</u> | <u>Hygr.</u> |
|------------------------------|--------------|--------------|--------------|
| <u>Fontinalis</u>            | 1.00         |              |              |
| <u>Scapania</u>              | .78          | 1.00         |              |
| <u>Hygroamblystegium</u> gr. | .71          | .63          | 1.00         |

TABLE VI

## COMMUNITY COEFFICIENTS BY BRYOPHYTES, SUMMER

|                              | <u>Font.</u> | <u>Hygr.</u> | <u>Scap.</u> | <u>Sci.</u> |
|------------------------------|--------------|--------------|--------------|-------------|
| <u>Fontinalis</u>            | 1.00         |              |              |             |
| <u>Hygroamblystegium</u> gr. | .84          | 1.00         |              |             |
| <u>Scapania</u>              | .84          | .80          | 1.00         |             |
| <u>Sciaromium</u>            | .62          | .72          | .65          | 1.00        |

bryophytes arranged by their similarities. It appears that Fontinalis and Scapania harbor many of the same insects, with Hygroamblystegium close to these in all but the March collections. Only the Sciaromium collections in summer appear to be notably different from collections of the other bryophytes, and even these differences are slight enough to be attributed to possible sampling error. It is immediately obvious that these bryophyte coefficients are higher than the stream coefficients. Such higher coefficients should be expected because, although they represent small portions of many streams, part of the range of conditions is eliminated, as reflected by the absence of the other bryophyte species and the presence of the species considered. This is but another reminder to us of the complexity of the stream environment in its relation to the biological response.

Differences in species composition of the insect fauna remaining in these hand-collected samples of aquatic bryophytes can be attributed to a number of causes: 1) Chance or sampling error. 2) Season of collection. 3) Differences between streams; these are both present physical conditions and recovery time since last scouring by ice, flood, forest fire runoff, pollution, etc. 4) Differences within the stream in substratum, current, water depth, light, and seasonal fluctuations in these. 5) Differences imposed by the bryophytes themselves in terms of current, sedimentation, light, and physical difference.

If one wishes to examine attribute number 5, then some of the preceding can be eliminated or reduced by finding places where the bryophyte faunas to be examined are adjacent to one another in the same stream in as homogeneous an area as possible and sample both on the same dates. While it is not possible to eliminate the different

bryophyte effects on current, sedimentation, light, etc., one can ascribe, with adequate, unbiased sampling, the differences to the bryophytes per se or to the microenvironmental conditions imposed by or occupied by each bryophyte species.

To compare the insect fauna in two closely adjacent bryophyte species, Fontinalis dalecarlica and Scapania were studied in the Toliver Falls collection site. As mentioned previously, both Fontinalis and Scapania occurred in Toliver Run in dripping water away from the main flow of the falls. In this instance (July 29) one handful of Scapania harbored six times as many total insects per gram as one handful of Fontinalis, while Fontinalis harbored twice as many individuals of Rhyacophila but had fewer of everything else. On the other hand, few abundant Scapania insects were excluded on Fontinalis: Simulium spp. averaged 418 on Scapania and none on Fontinalis while Leuctra dropped from 42 to .7 per gram. One could assume the difference in total numbers lies in the great amount of internal chambering in Scapania, whereas Fontinalis provides little more protection than a handful of strings. But these higher counts may well be related to the fact that Fontinalis has a heavy axis and is generally a heavier plant than Scapania.

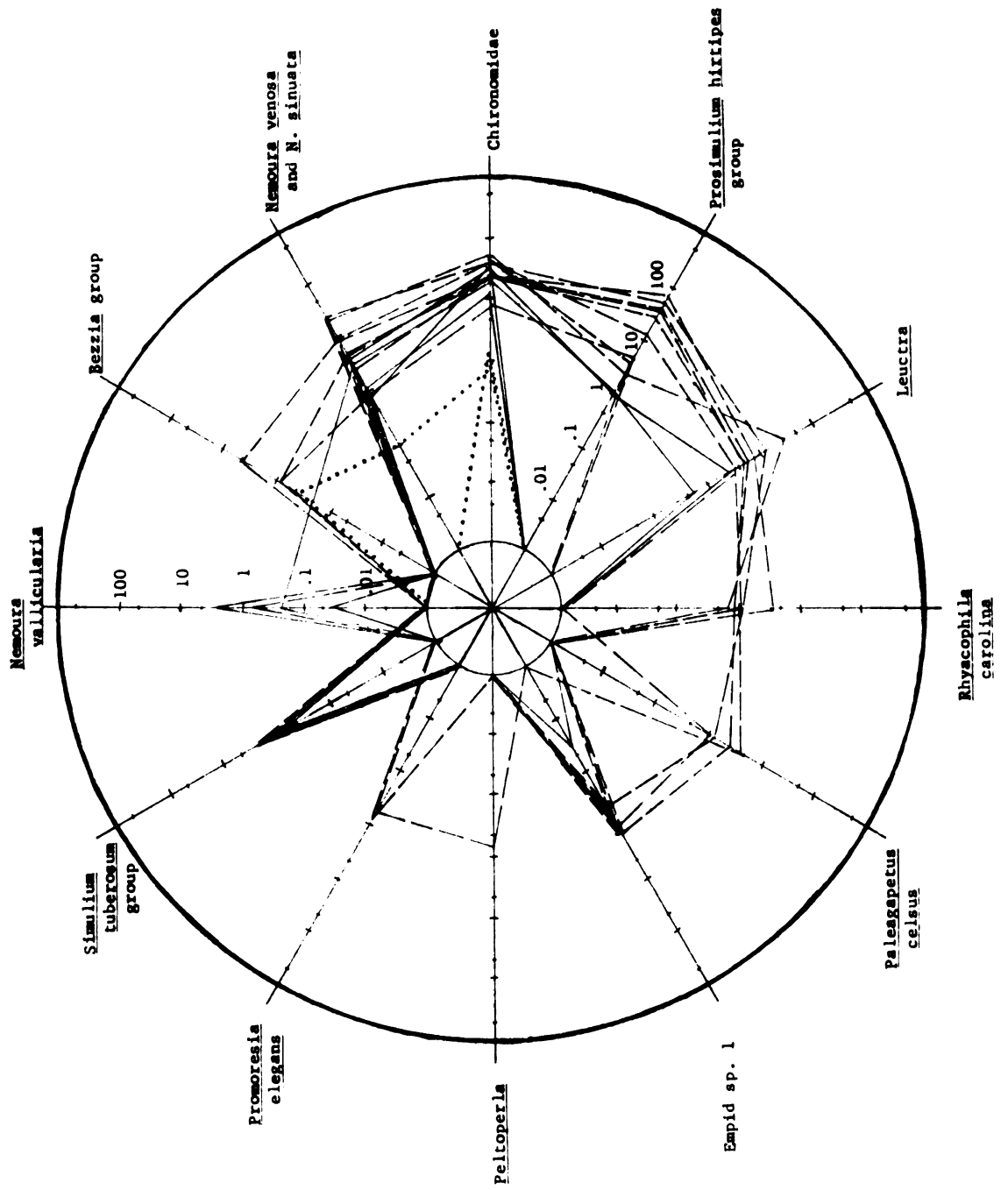
When comparing all the Scapania (7 collections), Fontinalis (4), and Sematophyllum marylandicum (2) (an occasional species on the edge of Toliver Run) collections for March (Plate 13), there are again differences both in kind and number of insects. Certainly the Sematophyllum insect faunal community is much less diverse, exhibiting only three of the top 20 species of insects and having counts an order of magnitude lower. On the other hand, Scapania is the most

PLATE 13. MARCH, TOLIVER RUN: RELATIVE NUMBER OF INSECTS IN THREE SPECIES OF BRYOPHYTES. EACH LINE REPRESENTS A DIFFERENT HANDFUL, BUT ALL ARE ON THE SAME COLLECTION DATE. SCALE IS  $\text{LOG}_{10}$  OF NUMBERS OF INDIVIDUALS PER GRAM OF BRYOPHYTE.

———Fontinalis dalecarlica

———Scapania undulata

.....Sematophyllum marylandicum



diverse by having four species (Rhyacophila carolina group, Paleagapetus celsus, Peltoperla sp., and Promoresia elegans) which are totally absent from both Fontinalis and Sematophyllum clumps. Further, Scapania has higher counts per gram dry weight of all insects in nearly every collection. Although these three bryophytes can be expected to produce different physical influences, the presence also reflects habitat differences such as falls, interfalls, and edge areas, respectively. It is possible that such habitat differences explain the mutual exclusion of the Simulium tuberosum group and the gilled Nemoura, for both of these occur in Fontinalis and Scapania, but never in the same collection.

#### Comparison of streams

A glance at Tables VII-X shows that streams range from very similar (community coefficient of .86) to very different (.07). Those with the highest coefficients with other streams are generally those with the most species of insects, and the lowest coefficient series coincide with streams having the fewest species. For ease of comparison, the items in the tables have been grouped by dominant bryophyte. Any attempt to order these streams according to their coefficients results in a multidimensional chaos due to the complicated interrelationships. But, the overall picture, when partitioned into subsets, shows a high similarity within a bryophyte species, even though an occasional interspecies pair may also be highly correlated.

Small coefficients and a small number of species are exhibited by Little Bennett Creek and Pidcock Creek. These small, sluggish streams would stand out, even to the casual observer, as being quite different from the other cool, rocky, mountain streams. In March the



TABLE VII  
COMMUNITY COEFFICIENTS BY STREAMS, MARCH

|      | To   | De   | Ro   | Hy   | Gr   | Sd   | Si   | SiMt | LB   | WBU  | WBe  | My   |
|------|------|------|------|------|------|------|------|------|------|------|------|------|
| To   | 1.00 |      |      |      |      |      |      |      |      |      |      |      |
| De   | .85  | 1.00 |      |      |      |      |      |      |      |      |      |      |
| Ro   | .64  | .64  | 1.00 |      |      |      |      |      |      |      |      |      |
| Hy   | .62  | .59  | .73  | 1.00 |      |      |      |      |      |      |      |      |
| Gr   | .54  | .59  | .58  | .62  | 1.00 |      |      |      |      |      |      |      |
| Sd   | .25  | .43  | .44  | .48  | .62  | 1.00 |      |      |      |      |      |      |
| Si   | .34  | .32  | .46  | .50  | .56  | .52  | 1.00 |      |      |      |      |      |
| SiMt | .22  | .17  | .26  | .29  | .33  | .27  | .44  | 1.00 |      |      |      |      |
| LB   | .46  | .39  | .41  | .44  | .63  | .35  | .46  | .44  | 1.00 |      |      |      |
| WBU  | .22  | .26  | .26  | .21  | .42  | .27  | .33  | .40  | .44  | 1.00 |      |      |
| WBe  | .08  | .10  | .07  | .08  | .19  | .17  | .13  | .29  | .27  | .57  | 1.00 |      |
| My   | .33  | .31  | .41  | .32  | .37  | .56  | .38  | .31  | .29  | .15  | .20  | 1.00 |

|    |                      |      |                                      |
|----|----------------------|------|--------------------------------------|
| To | Toliver Run          | SiMt | Mountain Lake trib. to Sinking Creek |
| De | Deep Creek tributary | Si   | Sinking Creek                        |
| Ro | Goose Creek          | LB   | Little Bennett Creek                 |
| Hy | Hoyes Run            | WBU  | Seneca Creek, Burroughs trib.        |
| Gr | Gramlich Run         | WBe  | Seneca Creek, Bell trib.             |
| Sd | Sideling Hill Creek  | My   | Muddy Creek                          |



TABLE VIII

## COMMUNITY COEFFICIENTS BY STREAMS, MAY

|     | LB   | Gr   | Gi   | Tot  | De   | To   | Py   | Ne   | My   |
|-----|------|------|------|------|------|------|------|------|------|
| LB  | 1.00 |      |      |      |      |      |      |      |      |
| Gr  | .48  | 1.00 |      |      |      |      |      |      |      |
| Gi  | .51  | .53  | 1.00 |      |      |      |      |      |      |
| Tot | .52  | .62  | .72  | 1.00 |      |      |      |      |      |
| De  | .32  | .50  | .47  | .53  | 1.00 |      |      |      |      |
| To  | .44  | .44  | .57  | .59  | .78  | 1.00 |      |      |      |
| Py  | .42  | .59  | .71  | .59  | .44  | .65  | 1.00 |      |      |
| Ne  | .44  | .57  | .51  | .43  | .40  | .48  | .55  | 1.00 |      |
| My  | .25  | .42  | .48  | .38  | .26  | .37  | .30  | .25  | 1.00 |

|     |                        |
|-----|------------------------|
| LB  | Little Bennett Creek   |
| Gr  | Gramlich Run           |
| Gi  | Ginseng Run            |
| Tot | Tolliver Run tributary |
| De  | Deep Creek tributary   |
| To  | Tolliver Run           |
| Py  | Piney Creek            |
| Ne  | Neds Run               |
| My  | Muddy Creek            |

TABLE IX

## COMMUNITY COEFFICIENTS BY STREAMS, JUNE

|    | Gr   | LB   | De   | To   | My   | Hy   |
|----|------|------|------|------|------|------|
| Gr | 1.00 |      |      |      |      |      |
| LB | .60  | 1.00 |      |      |      |      |
| De | .50  | .66  | 1.00 |      |      |      |
| To | .56  | .32  | .70  | 1.00 |      |      |
| My | .56  | .28  | .56  | .56  | 1.00 |      |
| Hy | .50  | .35  | .50  | .50  | .65  | 1.00 |

Gr Gramlich Run  
 LB Little Bennett Creek  
 De Deep Creek tributary  
 To Toliver Run  
 My Muddy Creek  
 Hy Hoyes Run

TABLE X

|    |                      |
|----|----------------------|
| My | Muddy Creek          |
| Po | Pohopoco Creek       |
| Mu | Mud Run              |
| Sw | Swamp Run            |
| To | Toliver Run          |
| La | Laurel Run           |
| Hk | Hoch Run             |
| Sa | Saw Creek            |
| Di | Dingman's Creek      |
| El | Elk Creek            |
| Hy | Hoyes Run            |
| Gi | Ginseng Run          |
| Jo | Johns Run            |
| Rk | Rock Castle Creek    |
| Pi | Pidcock Creek        |
| LB | Little Bennett Creek |

**TABLE X**  
**COMMUNITY COEFFICIENTS BY STREAMS, SUMMER**

|    | My   | Po   | Mu   | Sw   | To   | La   | Hk   | Sa   | Dl   | EI   | Hy   | G1   | Jo   | Rk   | P1   | Lb   |
|----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| My | 1.00 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Po | .74  | 1.00 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Mu | .74  | .76  | 1.00 |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Sw | .62  | .71  | .75  | 1.00 |      |      |      |      |      |      |      |      |      |      |      |      |
| To | .54  | .54  | .58  | .70  | 1.00 |      |      |      |      |      |      |      |      |      |      |      |
| La | .55  | .67  | .71  | .69  | .61  | 1.00 |      |      |      |      |      |      |      |      |      |      |
| Hk | .59  | .63  | .63  | .51  | .65  | .69  | 1.00 |      |      |      |      |      |      |      |      |      |
| Sa | .72  | .70  | .67  | .69  | .61  | .52  | .86  | 1.00 |      |      |      |      |      |      |      |      |
| Dl | .75  | .65  | .69  | .60  | .64  | .47  | .68  | .75  | 1.00 |      |      |      |      |      |      |      |
| El | .68  | .77  | .69  | .72  | .60  | .64  | .68  | .68  | .67  | 1.00 |      |      |      |      |      |      |
| Hy | .71  | .72  | .66  | .68  | .61  | .61  | .71  | .71  | .67  | .80  | 1.00 |      |      |      |      |      |
| G1 | .68  | .76  | .66  | .64  | .64  | .68  | .64  | .61  | .56  | .77  | .79  | 1.00 |      |      |      |      |
| Jo | .54  | .73  | .63  | .62  | .51  | .57  | .53  | .58  | .55  | .65  | .61  | .57  | 1.00 |      |      |      |
| Rk | .44  | .52  | .53  | .51  | .39  | .39  | .43  | .43  | .49  | .45  | .43  | .41  | .55  | 1.00 |      |      |
| P1 | .42  | .49  | .34  | .48  | .46  | .72  | .49  | .40  | .45  | .51  | .57  | .65  | .44  | .48  | 1.00 |      |
| Lb | .29  | .34  | .23  | .33  | .36  | .30  | .36  | .26  | .41  | .49  | .42  | .42  | .23  | .17  | .62  | 1.00 |

equally sluggish Seneca Creek tributaries show similar dissimilarity when compared with most of the other streams. Perhaps this is because they, too, have few species of insects.

As mentioned above, the streams with the greatest number of insect species have the highest coefficients, even with the streams supporting a low number of insect species. This may be due to the relatively small total number of species (150), so that any stream with many species nearly covers the species repertoire for a particular season. Thus, it appears as though conditions which restrict the bryophytes can differ in several directions which, in turn, differentially influence the various insects.

In general, we might state that the similarity among streams with the same dominant bryophyte is greater than their similarity with streams having other dominants. Toliver Run and Deep Creek tributary are exceptions. In the three seasons sampled, the Toliver Run and Deep Creek tributary pair always have the highest coefficient. Both of these streams have Fontinalis and Scapania, but Toliver has Scapania as a dominant, while Deep Creek has Hygroamblystegium as its dominant. Since both streams are at a similar elevation in Garrett County, Maryland, this may be one of the major factors influencing their similarity. But it has already been pointed out that Scapania is relatively uncommon. Its presence in a stream may indicate a selective set of characteristics which influence the insects as well as Scapania, thus accounting for the insect faunal similarity of these two proximal streams. In this same connection, we should note the similarity of the three Scapania streams in the summer collections: Toliver Run, Laurel Run, and Hoch Run. But it is also noteworthy that Hoch Run is most similar to Saw Creek. This connection is difficult to ex-

plain, for the two streams occur at different elevations in different counties in Pennsylvania and do not give a strikingly similar appearance, wherein Saw Creek is much wider than Hoch Run. Nevertheless, a glance at the righthand coefficient of each stream set will point out that most of the streams are most similar to others having the same dominant bryophyte, and certain clumps of similar streams might be inferred from the table. As these coefficients have no confidence limits, it is dangerous to rely heavily on many of the slight differences indicated, and I will not attempt to offer any explanation for the clumps.

#### Insect communities by seasons

The relative abundances and species relationships of insects with the bryophyte species can be inferred by the use of polygonal graphs. Hutchinson (1940) and Davidson (1947) have used polygonal graphs to show environmental parameters and taxonomic characters, respectively. In the present study, the graph is adapted to show community relationships. The parameters are the insect species, which are shown as mean number per gram by a  $\log_{10}$  scale on each radius. These insects have been arranged from high to low frequency (based on Tables XII-XVI in the Appendix), with the most frequent on the right side of the graph and least frequent on the left. Before obtaining the means, the collection data were organized by bryophyte species. For each bryophyte species, means of insect counts were first computed for that species in each stream. Then, the mean of these was computed to obtain an overall mean for the bryophyte among the stream types. The Hygroamblystegium group required a third mean: after each bryophyte mean was obtained, these were averaged to obtain

the final mean. (Explanation of the Hygroamblystegium group is found in the bryophyte section.)

Based on the polygonal graphs, certain communities become apparent in the five seasonal groups. Figure 3 compares the seasonal aspects of the more abundant ones.

In March (Plate 14), the chironomids dominate Fontinalis dalecarlica and the Hygroamblystegium group, while the Prosimulium hirtipes group larvae are most abundant on Scapania undulata. Fluctuations in abundance occur among most of the other insects, but certain differences are striking: 1) The Ephemerella invaria group occurs exclusively with the Hygroamblystegium group. 2) Fontinalis is marked by the absence of Pericoma, Bezzia, Empidae, and Dasyhelea, all of which are small Diptera with poor or no adaptation for clinging, and F. dalecarlica lacks the blimp-shaped Peltoperla, possibly for the same reason. 3) The caddisfly Rhyacophila carolina group is much more abundant with Scapania than with Hygroamblystegium and it is absent on F. dalecarlica; the caddisflies Cheumatopsyche and Hydroptila are absent in S. undulata communities. Since the sampling for this survey was not designed to provide a rigorous test of this kind of correlation, no confidence intervals can be provided for these absences, nor do I have any conjectures on the possible reasons for these apparent relationships.

By May (Plate 15), the numbers have greatly increased for most insects, as seen in Fig. 3, and now chironomids on S. undulata show an order of magnitude lower count than for the other bryophytes. In fact, during this period, the insect fauna is poorer in total species and numbers in S. undulata turf, when compared to the other two bryo-

Figure 3. Relative Abundance in the Five Collected Seasons

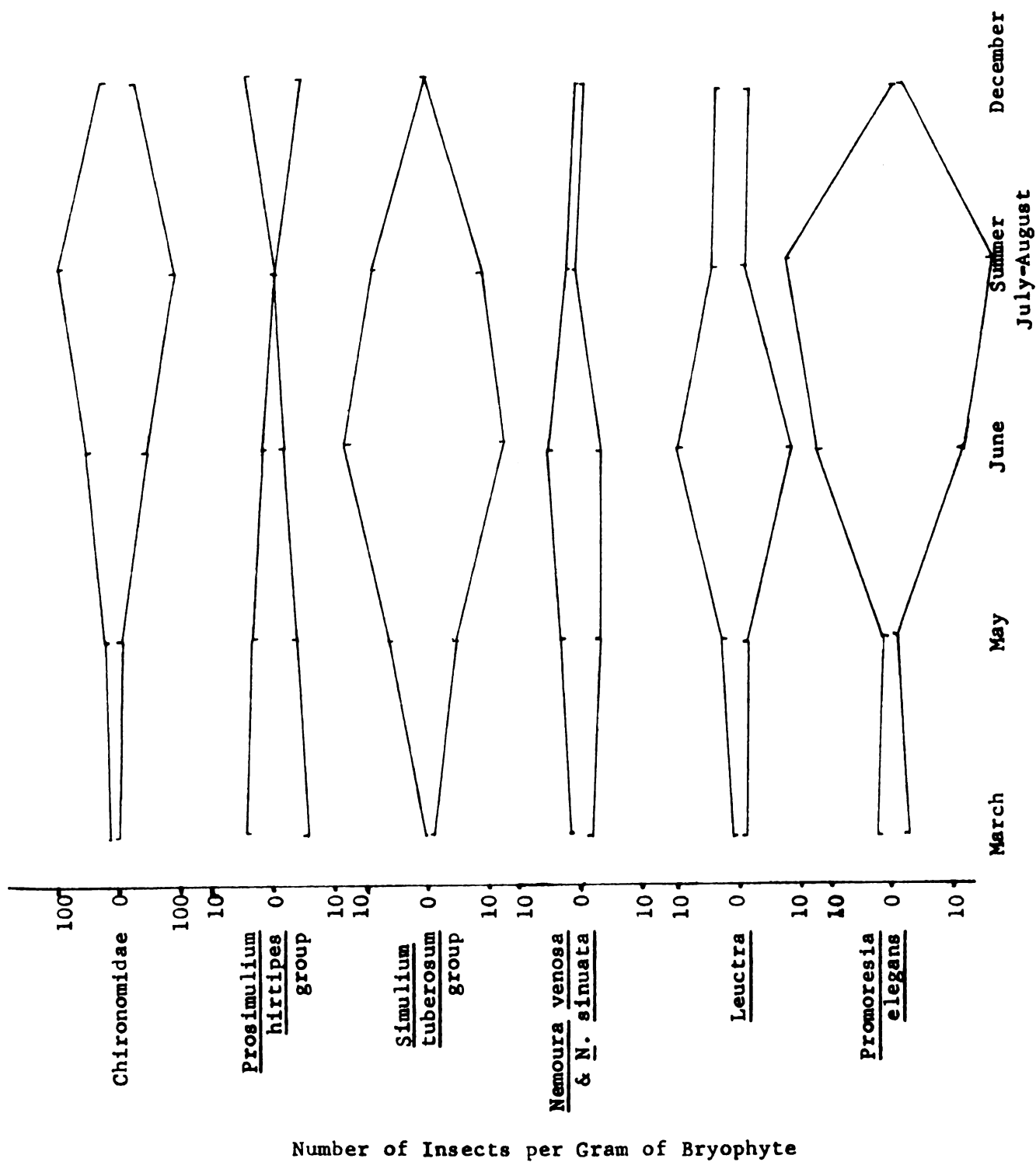


Figure 3.

phyte groups. This might be expected from S. undulata's limited distribution and the small total number of collections (6). It should also be pointed out that if one aquatic insect has a very high restriction to S. undulata and is at the same time very abundant, it may be responsible for keeping the other insects low in this bryophyte in various direct ways.

Beginning in May and becoming very obvious in June (Plate 16) is the scarcity of Promoresia elegans in S. undulata, while Baetis is totally absent in the June collections of S. undulata. On the other hand, there are much larger Leuctra and Simulium tuberosum group populations in Scapania than in the other bryophytes, while the emerging Prosimulium hirtipes group is nearly absent in all three. (Note that the chironomids have been omitted on this graph to permit comparison of more selective species.)

Summer (Plate 17) shows little major difference among the bryophytes except for the absence of large insects in S. undulata: Togoperla, Pteronarcys spp., Cheumatopsyche. Furthermore, Pteronarcys biloba on F. dalecarlica and Pteronarcys proteus among the Hygroamblystegium group are mutually exclusive. At this time, extremely high counts of midges are obtained, reaching as much as 2500 per gram in one Scapania collection.

In December (Plate 18), the comparison is really one between Muddy Creek and Toliver Run. Only 17 taxa were present, 9 on F. dalecarlica and 12 on S. undulata. Thus, only 4 occurred on both: the Prosimulium hirtipes group, Chironomidae, Empidae, and Hydropsyche. These differences in taxa are probably due to multiple stream differences as well as bryophyte differences.

PLATE 14. MARCH: RELATIVE NUMBERS OF INSECTS PER GRAM DRY WEIGHT  
OF BRYOPHYTE

—— Hygroamblystegium fluviatile group

—— Fontinalis dalecarlica

..... Scapania undulata

The scale is  $\log_{10}$  of insects per gram of bryophyte.

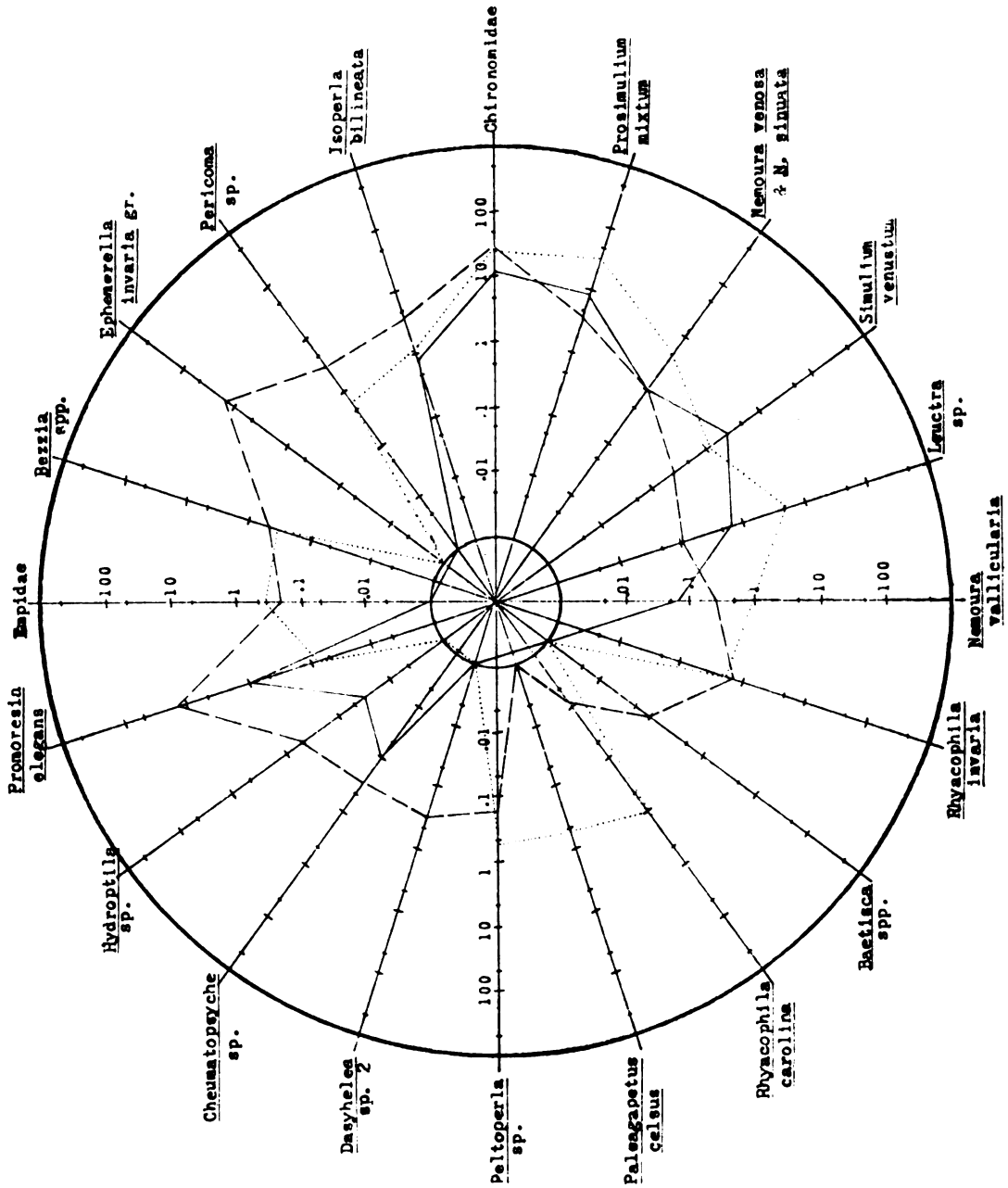


PLATE 15. MAY: RELATIVE NUMBER OF INSECTS PER GRAM DRY WEIGHT  
OF BRYOPHYTE

———Hygroamblystegium fluviatile group

———Fontinalis dalecarlica

.....Scapania undulata

The scale is  $\log_{10}$  of insects per gram of bryophyte.

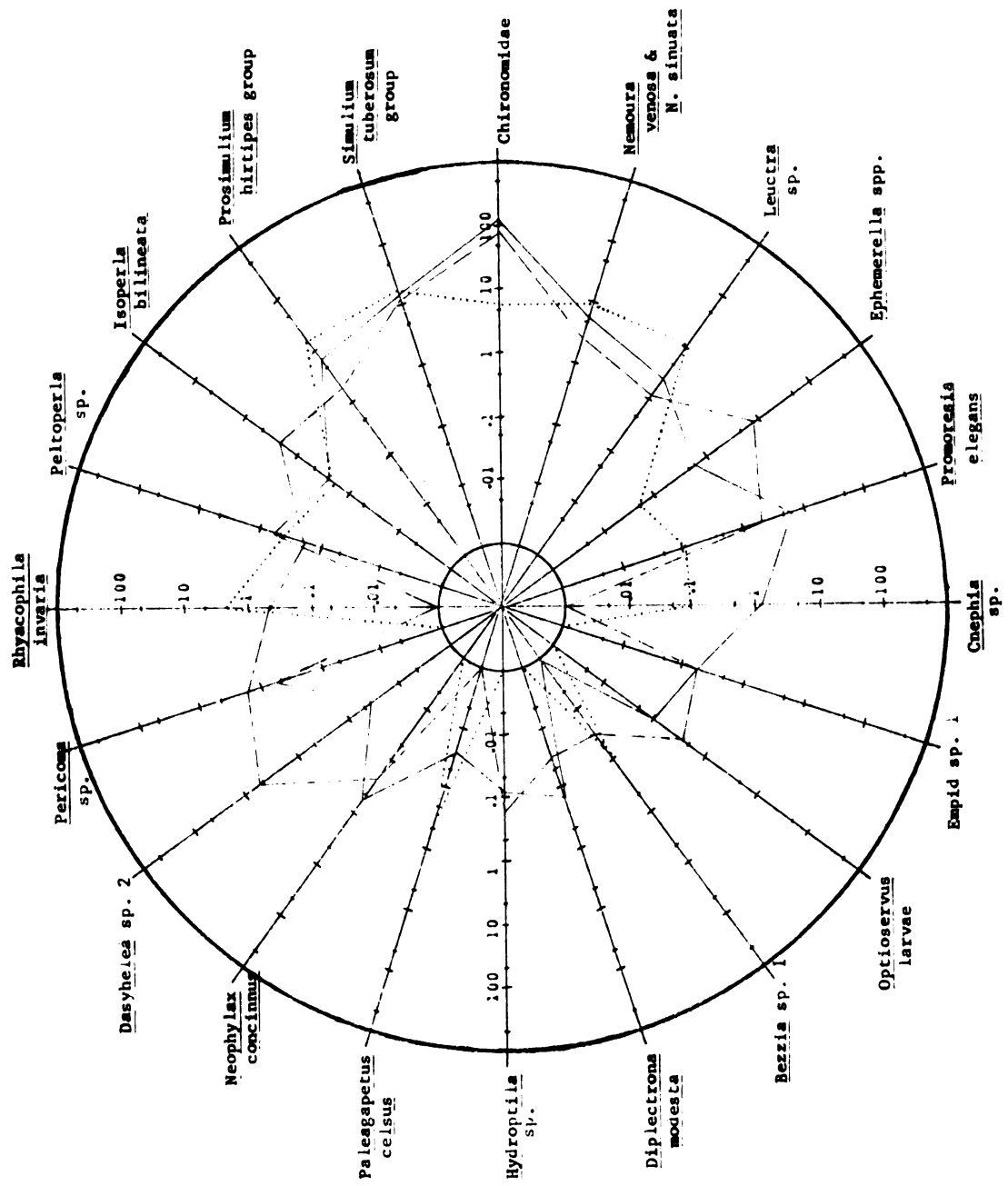




PLATE 16. JUNE: RELATIVE NUMBERS OF INSECTS PER GRAM DRY WEIGHT  
OF BRYOPHYTE

— — Hygroamblystegium fluviatile group

----- Fontinalis dalecarlica

..... Scapania undulata

The scale is  $\log_{10}$  of insects per gram of bryophyte.

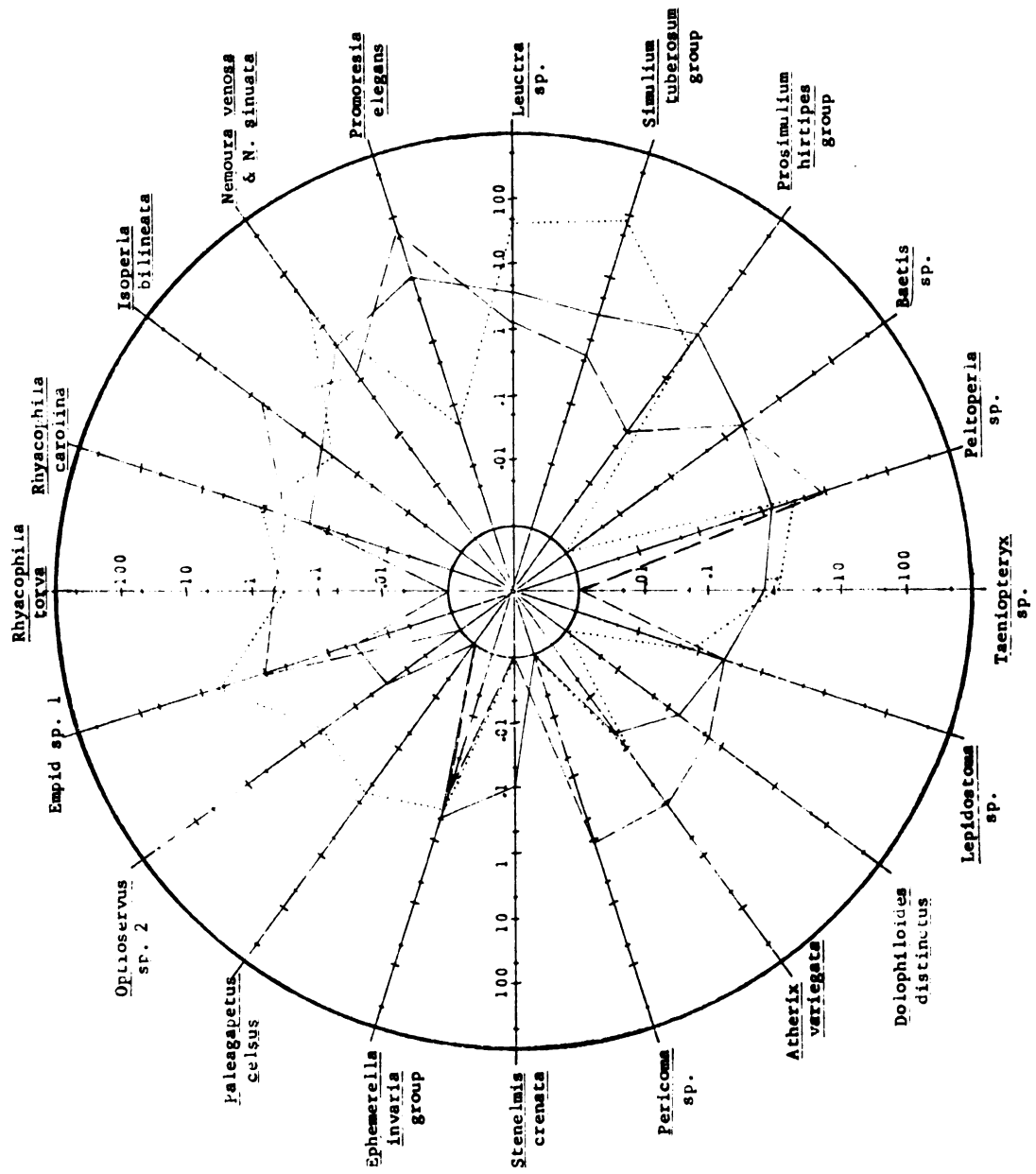


PLATE 17. MID-SUMMER: RELATIVE NUMBERS OF INSECTS PER GRAM DRY WEIGHT  
OF BRYOPHYTE

-- Hydroamblystegium fluviale group

----- Festinalis dalecarlica

..... Scapania undulata

The scale is  $\log_{10}$  of insects per gram of bryophyte.

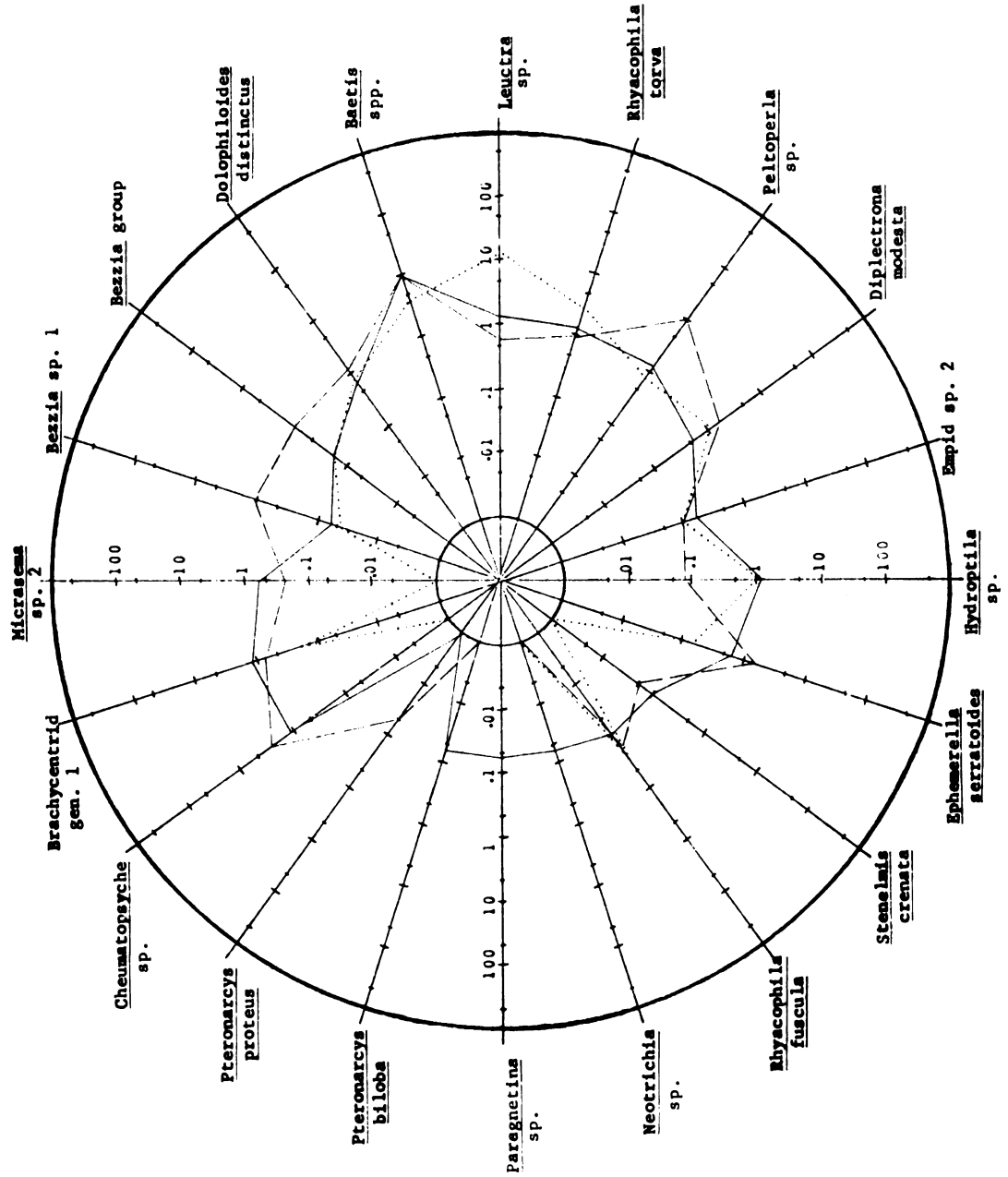
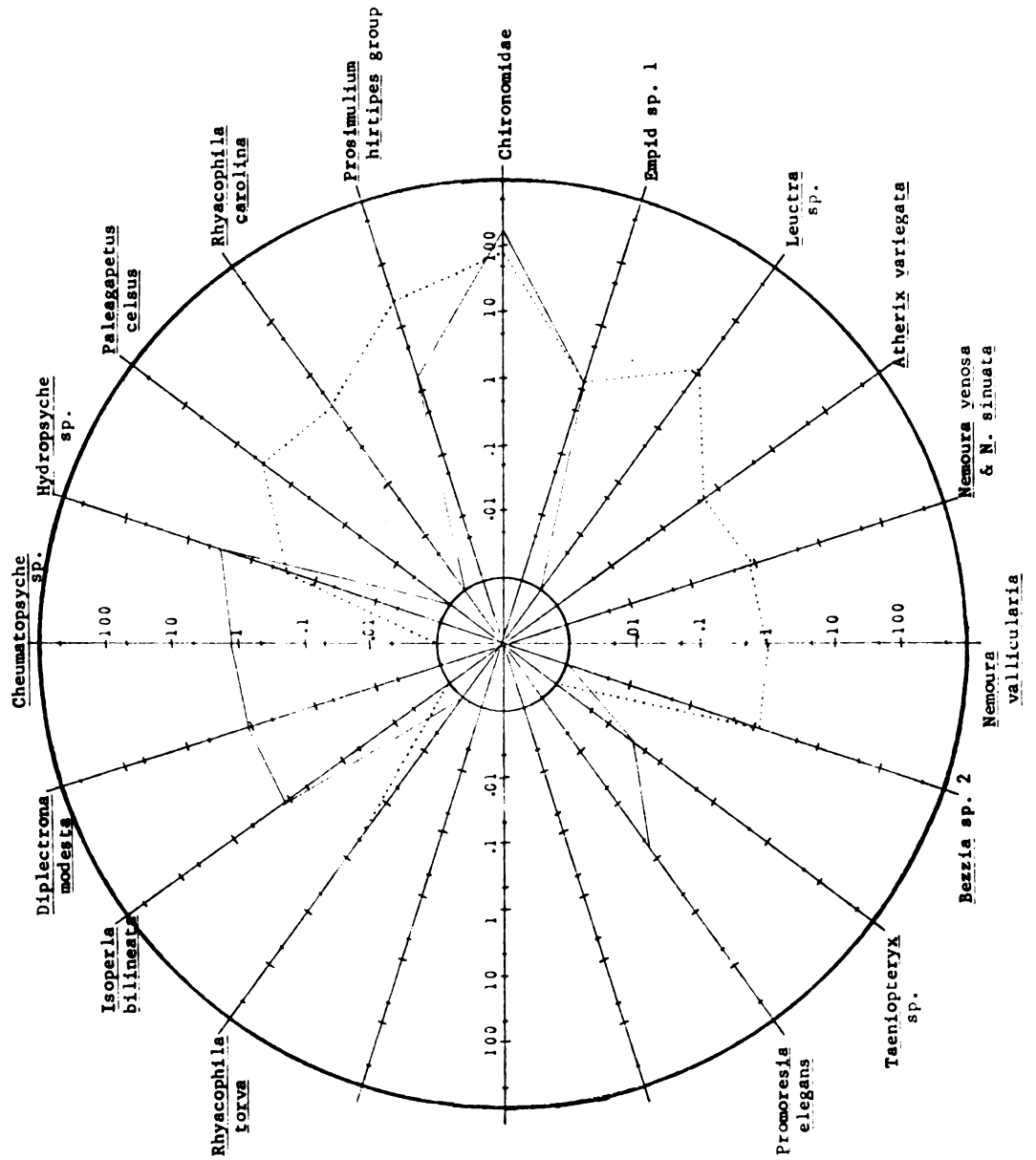


PLATE 18. DECEMBER: RELATIVE NUMBERS OF INSECTS PER GRAM DRY WEIGHT  
OF BRYOPHYTE

———Fontinalis dalecarlica

.....Scapania undulata





Seasonal pulses, as would be expected, are evidenced by high numbers of individuals and species in the mid-summer months, while a low point is reached in the March collections. A comparison of Toliver Run collections indicates that counts per gram of Chironomidae are higher in December than in March or May, but are nearly equal in June, while summer counts far surpass all other seasons. Meanwhile, the Prosimulium group and Leuctra also drop from December to March. This study was not designed to measure or explain these differences, so we cannot determine whether the higher counts in December are influenced by such things as the life cycles of the species, natural reduction of numbers, predation, or a seasonal preference for the bryophyte. Macan and Worthington, 1951, mention the rolling stone that gathers no moss. Perhaps the high December counts of insects are due to a migration to the stable, moss-covered rocks during a time when ice and heavy snowmelt loads in Toliver Run could dislodge insects from other areas. Furthermore, riffles, with their moss-covered rocks, are usually the last part of the stream to freeze, thus providing the most likely spot for an insect to receive flowing water and food. "Mosses and liverworts often form extensive swards where the substratum is rocky or stony, and they profoundly influence the fauna by providing a foothold for animals which otherwise would be swept away by the current." (Macan and Worthington, 1951)

From the seasonal data, one can approximate the bryophyte-insect faunal communities. (Refer to Fig. 3 for the seasonal distribution.)

Bryophytes in general:

Chironomidae  
Prosimulium hirtipes group  
Simulium tuberosum group

Hygroamblystegium group:

Ephemerella spp.  
Pteronarcys proteus  
Pericoma

Bryophytes in general (cont.):      Hygroamblystegium group (cont.):

Isoperla bilineata  
Nemoura spp.  
Dolophiloides distinctus  
Dasyhelea spp.  
Bezzia spp.

Rhyacophila invaria  
Micrasema spp.  
Promoresia elegans  
Peltoperla sp.  
Baetis spp.  
Empididae

Fontinalis dalecarlica

Micrasema spp.  
Pteronarcys biloba  
Cheumatopsyche  
Chimarra aterrima  
Promoresia elegans  
Baetis spp.

Scapania undulata

Paleagapetus celsus  
Rhyacophila carolina  
Rhyacophila invaria  
Optioservus  
Empididae

### Insect Biology and Ecology

(Table XI summarizes the habitat and adaptations.)

#### Coleoptera (beetles)

Among the beetles listed, only the Elmidae, the riffle beetles (larvae and adults), provide a significant part of the fauna. (The same is true in the European studies by Carpenter, 1927; Percival and Whitehead, 1929; and Frost, 1942.) In March their numbers were low except in Hoyes Run, where Promoresia elegans larvae represented the largest fraction of the population, even higher than the midge larvae of the Chironomidae. In May, Promoresia still was less important except for dominating the Muddy Creek bryo-fauna. By June, the numbers of Promoresia had increased an appreciable extent in both Hoyes Run and Muddy Creek, while remaining relatively unimportant in the Scapania-dominant Toliver. But in summer, its frequency was second only to the Chironomidae, reaching high counts among nearly every species of bryophyte. Then, with the onset of winter, only two adults appeared among the Muddy Creek and Toliver collections.

TABLE XI

## TAXONOMIC LIST OF INSECTS AND ADAPTATIONS

|                                             | lateral compression<br>small body | no ventral adhesion<br>attachment<br>weight | no swimming hairs<br>cover gills or none | Bryophytes |
|---------------------------------------------|-----------------------------------|---------------------------------------------|------------------------------------------|------------|
| <b>Coleoptera</b>                           |                                   |                                             |                                          |            |
| Dryopidae                                   |                                   |                                             |                                          |            |
| <u>Helichus</u> sp.                         |                                   | x                                           | x x                                      |            |
| Dytiscidae                                  |                                   |                                             |                                          |            |
| <u>Ilybius</u> sp.                          | x                                 | x                                           | x x                                      |            |
| <u>Hydroporus</u> sp.                       | x                                 | x                                           | x x                                      |            |
| Elmidae                                     |                                   |                                             |                                          |            |
| <u>Dubiraphia</u> sp. 1                     | x x x x                           |                                             | x x F                                    |            |
| <u>Microcylloepus</u> sp. 1                 | x x x x                           |                                             | x x                                      |            |
| <u>Optioservus</u> sp. 1                    | x x x x                           |                                             | x x H                                    |            |
| <u>Optioservus</u> sp. 2                    | x x x x                           |                                             | x x H                                    |            |
| <u>Promoresia elegans</u> LeConte           | x x x x                           |                                             | x x F H S                                |            |
| <u>Stenelmis crenata</u> (Say)              | x x x x                           |                                             | x x F                                    |            |
| Gyrinidae                                   |                                   |                                             |                                          |            |
| <u>Dineutus</u> sp.                         | x                                 | x                                           |                                          |            |
| Haliplidae                                  |                                   |                                             |                                          |            |
| <u>Brychius</u> sp.                         |                                   | x                                           | x x                                      |            |
| <u>Haliphus</u> sp.                         |                                   | x                                           | x x                                      |            |
| Hydraenidae                                 |                                   |                                             |                                          |            |
| <u>Limnebius</u> sp.                        |                                   | x                                           | x x                                      |            |
| Hydrophilidae                               |                                   |                                             |                                          |            |
| <u>Enochrus</u> sp.                         |                                   | x                                           | x x                                      |            |
| <u>Tropisternus</u> sp.                     |                                   | x                                           | x x                                      |            |
| Psephenidae                                 |                                   |                                             |                                          |            |
| <u>Ectoparia</u> ?                          |                                   |                                             | x x                                      |            |
| <b>Collembola</b>                           |                                   |                                             |                                          |            |
| Brachystomellidae                           |                                   |                                             |                                          |            |
| <u>Odontella lamellifera</u> (Axelson)      | x x                               |                                             | x x                                      |            |
| Entomobryidae                               |                                   |                                             |                                          |            |
| <u>Entomobrya griseoolivata</u> (Packard)   | x x                               |                                             | x x                                      |            |
| <u>Orchesella quinquefasciata</u> (Bourlet) | x x                               |                                             | x x                                      |            |
| Hypogastruridae                             |                                   |                                             |                                          |            |
| <u>Hypogastrura armatus</u> (Nicolet)       | x x                               |                                             | x x                                      |            |
| <u>Schotella glasgowi</u> (Folsom)          | x x                               |                                             | x x                                      |            |
| Isotomidae                                  |                                   |                                             |                                          |            |
| <u>Hydroisotoma schafferi</u> (Krausbauer)  | x x                               |                                             | x x                                      |            |
| <u>Isotoma violacea</u> Tullberg            | x x                               |                                             | x x                                      |            |
| <u>Isotoma viridis</u> Bourlet              | x x                               |                                             | x x                                      |            |
| <u>Isotomurus palustris</u> (Muller)        | x x                               |                                             | x x                                      |            |

|                                                     | lateral compression<br>small body<br>no ventral adhesion<br>attachment<br>weight<br>no swimming hairs<br>cover gills or none | Bryophytes |
|-----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|------------|
| Neanuridae                                          |                                                                                                                              |            |
| <u>Pseudachorutes lunatus</u> Folsom                | x x                                                                                                                          | x x        |
| Onychiuridae                                        |                                                                                                                              |            |
| <u>Onychiurus subtenius</u> Folsom                  | x x                                                                                                                          | x x        |
| Sminthuridae                                        |                                                                                                                              |            |
| <u>Sminturides aquaticus</u> (Bourlet)              | x x x                                                                                                                        | x x        |
| Tomoceridae                                         |                                                                                                                              |            |
| <u>Tomocerus flavescens</u> (Tullberg)              | x x                                                                                                                          | x x        |
| Diptera                                             |                                                                                                                              |            |
| Blephariceridae                                     |                                                                                                                              |            |
| <u>Blepharicera</u> sp.                             | x                                                                                                                            | x x        |
| Chironomidae                                        | x x x                                                                                                                        | x x F S H  |
| Dixidae                                             |                                                                                                                              |            |
| <u>Dixa</u> sp.                                     | x x                                                                                                                          | x x        |
| Dolichopodidae                                      |                                                                                                                              |            |
| <u>Hydrophorus</u> sp.                              | x                                                                                                                            | x x        |
| Empididae                                           |                                                                                                                              |            |
| Empid sp. 1                                         | x x x                                                                                                                        | x x F H    |
| Empid sp. 2                                         | x x x                                                                                                                        | x x H      |
| Empid sp. 3                                         | x x x                                                                                                                        | x x        |
| <u>Hemerodromia</u> cf. <u>rogatoris</u> Coquillett | x x x                                                                                                                        | x x F      |
| <u>Hemerodromia</u> cf. <u>seguyi</u> Vaillant      | x x x                                                                                                                        | x x F      |
| Heleidae                                            |                                                                                                                              |            |
| <u>Alluaudomyia</u> sp.                             | x x x                                                                                                                        | x x        |
| <u>Atrichopogon</u> sp.                             | x x x                                                                                                                        | x x        |
| <u>Bezzia</u> sp. 1                                 | x x x                                                                                                                        | x x F H S  |
| <u>Bezzia</u> spp.                                  | x x x                                                                                                                        | x x H      |
| <u>Dasyhelea</u> sp. 1                              | x x x                                                                                                                        | x x S      |
| <u>Dasyhelea</u> sp. 2                              | x x x                                                                                                                        | x x F H    |
| Muscidae                                            |                                                                                                                              |            |
| <u>Limnophora</u> sp.                               | x x                                                                                                                          | x x F      |
| Psychodidae                                         |                                                                                                                              |            |
| <u>Pericoma</u> sp.                                 | x x x                                                                                                                        | x x F H    |
| Rhagionidae                                         |                                                                                                                              |            |
| <u>Atherix variegata</u> Walker                     | x x x x                                                                                                                      | x x F H S  |
| Simulidae                                           |                                                                                                                              |            |
| <u>Cnephia mutata</u> (Malloch)                     | x x x                                                                                                                        | x x F S    |
| <u>Prosimulium hirtipes</u> group (Fries)           | x x x                                                                                                                        | x x S F H  |
| <u>Prosimulium magnum</u> Dyar & Shannon            | x x x                                                                                                                        | x x H      |
| <u>Prosimulium mixtum</u> Syme & Davies             | x x x                                                                                                                        | x x        |
| <u>Prosimulium rhizophorum</u> Stone & Jamnback     | x x x                                                                                                                        | x x        |
| <u>Simulium</u> nr. <u>gouldingi</u> Stone          | x x x                                                                                                                        | x x        |
| <u>Simulium impar</u> Davies, Peterson & Wood       | x x x                                                                                                                        | x x        |
| <u>Simulium parnassum</u> Malloch                   | x x x                                                                                                                        | x x S      |
| <u>Simulium tuberosum</u> (Lundstrom)               | x x x                                                                                                                        | x x F S H  |
| <u>Simulium venustum</u> Say                        | x x x                                                                                                                        | x x        |

|                                                    | lateral compression<br>small body | no ventral adhesion<br>attachment | weight | no swimming hairs<br>cover gills or none | Bryophytes |
|----------------------------------------------------|-----------------------------------|-----------------------------------|--------|------------------------------------------|------------|
| <u>Simulium</u> <u>verecundum</u> Stone & Jamnback | x x x                             |                                   |        | x x                                      |            |
| <u>Simulium</u> <u>vittatum</u> Zetterstedt        | x x x                             |                                   |        | x x                                      |            |
| Tabanidae                                          | x                                 |                                   |        | x x                                      |            |
| Thaumaleidae                                       |                                   |                                   |        |                                          |            |
| <u>Thaumalea</u> sp.                               | x x                               |                                   |        | x x                                      |            |
| Tipulidae                                          |                                   |                                   |        |                                          |            |
| <u>Antocha</u> sp.                                 | x                                 |                                   |        | x x                                      |            |
| <u>Dolichopeza</u> <u>americana</u> Needham        | x                                 |                                   |        | x x S                                    |            |
| <u>Hexatoma</u> nr. <u>longicornis</u> (Walker)    | x                                 |                                   |        | x x S                                    |            |
| <u>Hexatoma</u> nr. <u>spinosa</u> (Osten Sacken)  | x                                 |                                   |        | x x S                                    |            |
| <u>Limnophila</u> nr. <u>macrocera</u> (Say)       | x                                 |                                   |        | x x                                      |            |
| <u>Limnophila</u> sp.                              | x                                 |                                   |        | x x                                      |            |
| <u>Molophilus</u> sp.?                             | x                                 |                                   |        | x x                                      |            |
| <u>Ormosia</u> sp.?                                | x                                 |                                   |        | x x                                      |            |
| <u>Tipula</u> <u>collaris</u> Say                  | x                                 |                                   |        | x x H                                    |            |
| <u>Tipula</u> sp. 1                                | x                                 |                                   |        | x x                                      |            |
| <u>Tipula</u> sp. 2                                | x                                 |                                   |        | x x                                      |            |
| <u>Tipula</u> sp. 3                                | x                                 |                                   |        | x x                                      |            |
| <u>Tipula</u> sp. 4                                | x                                 |                                   |        | x x                                      |            |
| <u>Tipula</u> sp. 5                                | x                                 |                                   |        | x x                                      |            |
| <u>Tipula</u> sp. 6                                | x                                 |                                   |        | x x                                      |            |
| Maggot?                                            |                                   |                                   |        |                                          |            |
| Ephemeroptera                                      |                                   |                                   |        |                                          |            |
| Baetidae                                           |                                   |                                   |        |                                          |            |
| <u>Ameletus</u> sp.                                | x x x x                           |                                   |        |                                          |            |
| <u>Baetis</u> spp.                                 | x x x x                           |                                   |        |                                          | H F        |
| <u>Baetisca</u> <u>callosa</u> Traver              | x x x                             |                                   |        |                                          |            |
| <u>Baetisca</u> <u>carolina</u> Traver             | x x x                             |                                   |        |                                          |            |
| Caenidae                                           |                                   |                                   |        |                                          |            |
| <u>Caenis</u> sp.                                  | x x x                             |                                   |        | x x F                                    |            |
| Ephemerellidae                                     |                                   |                                   |        |                                          |            |
| <u>Ephemerella</u> <u>allegheniensis</u> Traver    | x x x                             |                                   |        | x                                        |            |
| <u>Ephemerella</u> <u>attenuata</u> McDunnough     | x x x                             |                                   |        | x F                                      |            |
| <u>Ephemerella</u> <u>catawba</u> Traver           | x x x                             |                                   |        | x H                                      |            |
| <u>Ephemerella</u> <u>deficiens</u> Morgan         | x x x                             |                                   |        | x                                        |            |
| <u>Ephemerella</u> <u>funeralis</u> McDunnough     | x x x                             |                                   |        | x                                        |            |
| <u>Ephemerella</u> nr. <u>invaria</u> (Walker)     | x x x                             |                                   |        | x H F                                    |            |
| <u>Ephemerella</u> <u>serratoides</u> McDunnough   | x x x                             |                                   |        | x H                                      |            |
| <u>Ephemerella</u> <u>subvaria</u> McDunnough      | x x x                             |                                   |        | x                                        |            |
| <u>Ephemerella</u> <u>temporalis</u> McDunnough    | x x x                             |                                   |        | x                                        |            |
| Heptageniidae                                      |                                   |                                   |        |                                          |            |
| <u>Epeorus</u> sp.                                 | x x                               |                                   |        |                                          |            |
| Leptophlebiidae                                    |                                   |                                   |        |                                          |            |
| <u>Paraleptophlebia</u> spp.                       | x x x x                           |                                   |        | x H                                      |            |

|                                                 | lateral compression | small body | no ventral adhesion | attachment | weight | no swimming hairs | cover gills or none | Bryophytes |
|-------------------------------------------------|---------------------|------------|---------------------|------------|--------|-------------------|---------------------|------------|
| Siphonuridae                                    |                     |            |                     |            |        |                   |                     |            |
| <u>Isonychia</u> sp.                            | x                   | x          | x                   | x          | x      |                   |                     |            |
| Hemiptera                                       |                     |            |                     |            |        |                   |                     |            |
| Veliidae                                        |                     |            |                     |            |        |                   |                     |            |
| <u>Microvelia</u> spp.                          |                     | x          | x                   | x          |        | x                 | x                   |            |
| Megaloptera                                     |                     |            |                     |            |        |                   |                     |            |
| Corydalidae                                     |                     |            |                     |            |        |                   |                     |            |
| <u>Nigronia</u> sp.                             |                     |            | x                   |            |        | x                 |                     |            |
| Sialidae                                        |                     |            |                     |            |        |                   |                     |            |
| <u>Sialis</u> sp.                               |                     |            | x                   |            |        |                   |                     |            |
| Odonata                                         |                     |            |                     |            |        |                   |                     |            |
| Cordulegasteridae                               |                     |            |                     |            |        |                   |                     |            |
| <u>Cordulegaster</u> sp.?                       |                     |            | x                   |            |        |                   |                     |            |
| Gomphidae                                       |                     |            |                     |            |        |                   |                     |            |
| <u>Gomphus</u> sp.?                             |                     |            | x                   |            |        |                   |                     |            |
| <u>Octogomphus</u> sp. ?                        |                     |            | x                   |            |        |                   |                     |            |
| Plecoptera                                      |                     |            |                     |            |        |                   |                     |            |
| Capniidae                                       |                     |            |                     |            |        |                   |                     |            |
| <u>Allocaupnia</u> sp.                          |                     | x          | x                   | x          |        | x                 | x                   |            |
| Isoperlidae                                     |                     |            |                     |            |        |                   |                     |            |
| <u>Isoperla bilineata</u> (Say)                 |                     | x          | x                   | x          |        | x                 | x                   | F S H      |
| <u>Isoperla duplicata</u> (Banks)               |                     | x          | x                   | x          |        | x                 | x                   |            |
| Leuctridae                                      |                     |            |                     |            |        |                   |                     |            |
| <u>Leuctra</u>                                  |                     | x          | x                   | x          |        | x                 | x                   | F S H      |
| Nemouridae                                      |                     |            |                     |            |        |                   |                     |            |
| <u>Nemoura sinuata</u> Wu                       |                     | x          | x                   | x          |        | x                 | x                   | F S H      |
| <u>Nemoura vallicularia</u> Wu                  |                     | x          | x                   | x          |        | x                 | x                   | F S H      |
| <u>Nemoura venosa</u> Banks                     |                     | x          | x                   | x          |        | x                 | x                   | F S H      |
| <u>Taeniopteryx</u> sp.                         |                     | x          | x                   | x          |        | x                 | x                   | H          |
| Peltoperlidae                                   |                     |            |                     |            |        |                   |                     |            |
| <u>Peltoperla</u> sp.                           |                     | x          | x                   | x          |        | x                 | x                   | F S H      |
| Perlidae                                        |                     |            |                     |            |        |                   |                     |            |
| <u>Acroneuria</u> sp.                           |                     | x          | x                   |            |        | x                 |                     |            |
| <u>Perlesta placida</u> (Hagen)                 |                     | x          | x                   |            |        | x                 |                     |            |
| <u>Phasganophora capitata</u> (Pictet)          |                     | x          | x                   |            |        | x                 |                     | F          |
| <u>Paragnetina</u> sp.                          |                     | x          | x                   |            |        | x                 |                     |            |
| Pteronarcidae                                   |                     |            |                     |            |        |                   |                     |            |
| <u>Pteronarcys biloba</u> Newman                |                     | x          | x                   |            |        | x                 |                     | F          |
| <u>Pteronarcys proteus</u> Newman               |                     | x          | x                   |            |        | x                 |                     | H          |
| Trichoptera                                     |                     |            |                     |            |        |                   |                     |            |
| Brachycentridae                                 |                     |            |                     |            |        |                   |                     |            |
| Brachycentrid gen. 1                            |                     | x          | x                   | x          | x      | x                 | x                   | H          |
| <u>Brachycentrus</u> nr. <u>numerosus</u> (Say) |                     | x          | x                   | x          | x      | x                 | x                   | H          |

|                                              | lateral<br>compression | small<br>body | no<br>ventral<br>adhesion | attachment<br>weight | no swimming<br>hairs | cover gills or<br>none | Bryophytes |
|----------------------------------------------|------------------------|---------------|---------------------------|----------------------|----------------------|------------------------|------------|
| <u>Brachycentrus</u> sp.                     | x                      | x             | x                         | x                    | x                    | x                      | H          |
| <u>Micrasema</u> sp. 1                       | x                      | x             | x                         | x                    | x                    | x                      |            |
| <u>Micrasema</u> sp. 2                       | x                      | x             | x                         | x                    | x                    | x                      | F H        |
| <u>Micrasema</u> sp. 3                       | x                      | x             | x                         | x                    | x                    | x                      | F H        |
| <b>Hydropsychidae</b>                        |                        |               |                           |                      |                      |                        |            |
| <u>Cheumatopsyche</u> spp.                   |                        | x             | x                         | x                    | x                    |                        | F H        |
| <u>Diplectrona modesta</u> Banks             |                        | x             | x                         | x                    | x                    |                        | F H        |
| <u>Hydropsyche</u> spp.                      |                        | x             | x                         | x                    | x                    |                        | F H S      |
| <u>Parapsyche apicalis</u> (Banks)           |                        | x             | x                         | x                    | x                    |                        |            |
| <b>Hydroptilidae</b>                         |                        |               |                           |                      |                      |                        |            |
| <u>Hydroptila</u> sp.                        | x                      | x             | x                         | x                    | x                    | x                      | F H        |
| <u>Hydroptilid</u> gen. 1 (gen. nov.)        | x                      | x             | x                         | x                    |                      | x                      | F H        |
| <u>Ithytrichia</u> sp.?                      | x                      | x             | x                         | x                    | x                    | x                      |            |
| <u>Mayatrachia</u> sp.                       | x                      | x             | x                         | x                    | x                    | x                      |            |
| <u>Neotrichia</u> sp.                        | x                      | x             | x                         | x                    | x                    | x                      | F          |
| <u>Oxyethira</u>                             | x                      | x             | x                         | x                    | x                    | x                      | F          |
| <u>Paleagapetus celsus</u> Ross              | x                      | x             | x                         | x                    | x                    | x                      | S          |
| <u>Tascobia</u> sp.                          | x                      | x             | x                         | x                    | x                    | x                      |            |
| <b>Lepidostomatidae</b>                      |                        |               |                           |                      |                      |                        |            |
| <u>Lepidostoma americana</u> (Banks)         | x                      | x             |                           | x                    | x                    | x                      | H          |
| <u>Lepidostoma</u> sp.                       | x                      | x             |                           | x                    | x                    | x                      | H F        |
| <b>Limnephilidae</b>                         |                        |               |                           |                      |                      |                        |            |
| <u>Neophylax concinnus</u> McLachlan         | x                      | x             |                           | x                    | x                    | x                      | H          |
| <u>Neophylax consimilis</u> Betten           | x                      | x             |                           | x                    | x                    | x                      |            |
| <u>Neophylax oligius</u> Ross                | x                      | x             |                           | x                    | x                    | x                      |            |
| <u>Platycentropus</u> sp.                    |                        | x             |                           | x                    | x                    |                        |            |
| <u>Pycnopsyche luculenta</u> (Betten)        |                        | x             |                           | x                    | x                    |                        | F          |
| <u>Pycnopsyche cf. scabripennis</u> (Rambur) |                        | x             |                           | x                    | x                    |                        | F          |
| <b>Odontoceridae</b>                         |                        |               |                           |                      |                      |                        |            |
| <u>Psilotreta</u> sp. 1                      |                        | x             |                           | x                    | x                    | x                      | H          |
| <u>Psilotreta</u> sp. 2                      |                        | x             |                           | x                    | x                    | x                      | H          |
| <b>Philopotamidae</b>                        |                        |               |                           |                      |                      |                        |            |
| <u>Chimarra aterrima</u> Hagen               |                        | x             |                           | x                    | x                    | x                      | F          |
| <u>Dolophiloides distinctus</u> (Walker)     |                        | x             |                           | x                    | x                    | x                      | S F H      |
| <b>Psychomyiidae</b>                         |                        |               |                           |                      |                      |                        |            |
| <u>Polycentropus</u> sp.                     |                        | x             |                           |                      | x                    | x                      |            |
| <b>Rhyacophilidae</b>                        |                        |               |                           |                      |                      |                        |            |
| <u>Glossosoma</u> sp.                        |                        | x             |                           | x                    | x                    | x                      |            |
| <u>Rhyacophila nr. carolina</u> Banks        |                        | x             |                           |                      | x                    | x                      | S          |
| <u>Rhyacophila fuscula</u> (Walker)          |                        | x             |                           |                      | x                    | x                      | F          |
| <u>Rhyacophila nr. invaria</u> (Walker)      |                        | x             |                           |                      | x                    | x                      | S H        |
| <u>Rhyacophila minora</u> Banks              |                        | x             |                           |                      | x                    | x                      |            |
| <u>Rhyacophila torva</u> Hagen               |                        | x             |                           |                      | x                    | x                      | H          |
| <u>Rhyacophila</u> sp. 2 (see Flint, 1962)   |                        | x             |                           |                      | x                    | x                      |            |
| <u>Rhyacophila</u> sp. 5 (see Flint, 1962)   |                        | x             |                           |                      | x                    | x                      |            |



### Collembola (Springtails)

Although the Collembola frequent the surface of ponds and lakes and inhabit the cushions of terrestrial bryophytes, they are relatively unimportant among the aquatic bryophytes of rapid waters. While their tiny size fits one characteristic for bryo-fauna, their mode of locomotion--a spring on the abdomen--would be difficult to maneuver inside the mat, and it would lead to an ocean-ward trip if used outside. Only the common Isotomurus palustris appeared in more than two collections.

Whereas their role in the bryophytes of mountain streams seems unimportant, one collembolan distribution is interesting, for Orchesella quinquefasciata from Toliver Run was previously unknown in North America (Richard Snider, pers. comm.). And Hydroisotoma schafferi from Little Bennett Creek is blind--an atypical form.

### Diptera (Flies)

"The Chironomidae provide by far the largest numbers of insect larvae and reach their greatest development among thick mossy growths such as occur at Harewood Bridge, Pool Weir and on mossy stones at Grassington and similar places." (Percival and Whitehead, 1930)

Certainly the chironomids are no exception in this study, where they reach counts as high as 2500 per gram dry weight of moss in summer and appear as the most frequent insect in every season, although in some of the March collections they were surpassed in numbers by other insects: Prosimulium spp. and Ephemerella spp. They reach their highest numbers in the mats and turfs, not the Fontinalis streamers. Because of the loose nature of Fontinalis dalecarlica, many of these larvae are of the case-building type or inhabit the protected

leaf bases, while the highest numbers of individuals occur in mats and turfs of other bryophytes. In his discussion of adaptations, Muttkowski (1929) points out that insects of specialized habitats (such as these) usually have generalized feeding habits. The Chironomidae, as a family, are detritus-feeders, herbivores, and carnivores. Among the moss inhabitants, the common Hydraeninae are phytophagous and detritus-feeders. Percival and Whitehead (1929) report that Chironomidae feed on diatoms, the major constituent of the bryophyte community flora (author, unpub. data).

Second to the Chironomidae, one of the species of Simuliidae (black flies) usually outnumbers the other insects: in March, the Prosimulium hirtipes group; in May, the Simulium tuberosum complex; in June the Simulium tuberosum complex is third most frequent with the stonefly Leuctra being more frequent but often less abundant, and in mid-summer, the Simulium tuberosum complex is surpassed in frequency by Promoresia elegans; in December the Prosimulium hirtipes group again becomes second most frequent. The Prosimulium group was not encountered after June 19. Other investigators (Davies, Peterson, & Wood, 1962) have indicated that adults of this group emerge April through June. Perhaps their absence in the present study indicates they have all either emerged or died. These same investigators indicate that Simulium tuberosum adults emerge in late May throughout the summer, and indeed in the present study they were encountered in the last samples which were taken in August, but were not encountered in December. In the present study of the middle Appalachians, the Prosimulium group over-wintered as larvae and even by late March a few pupae had developed. Meanwhile, Simulium spp. apparently overwinter

as eggs; a few tiny larvae appear in March, but their peak abundance is in May, at which time very few pupae are formed.

The Prosimulium hirtipes larvae from Toliver Run, June 11, 1966, and Muddy Creek, March 22, 1966, are close to Prosimulium mixtum Syme & Davies, (Davies, pers. comm.) and probably represent the first record of this species in the middle Appalachians. (They were first named in 1958 from Ontario specimens.) Others of the Prosimulium hirtipes group include larvae from Toliver Run (Dec. 25, 1965) which are close to Prosimulium saltus (Davies, pers. comm.). Prosimulium rhizophorum (not included in the Ontario studies) and Prosimulium magnum both occur in Gramlich Run.

Another recently described species, Simulium impar Davies, Peterson, & Wood (1962), occurs in Toliver Run (pupae: June 11, 1966) and Little Bennett Creek (larvae: May 8, 1966). Other species contributing possible Maryland records include Simulium vittatum (pupae: Seneca Creek tributary at Burroughs' and Bell's, March 27, 1965); Simulium venustum (larvae: Toliver Run, June 19, July 9, 1965; June 11, 1966); Simulium parnassum (larvae: Toliver Run, June 19, 1965); Simulium verecundum (larvae: Muddy Creek, June 11, 1966); Simulium nr. furculatum or gouldingi (larvae: Saw Creek, July 30, 1965). A Simulium (Eusimulium) represents a possible new species (larvae: Saw Creek, July 30, 1965).

Although feeding habits of Simuliidae were not observed in the present study, Percival and Whitehead (1929) report that the Simulium reptans gut contains moss, diatoms, and other algae. Its method of filter feeding suggests that the moss entered as detrital fragments and may not have been digested. The author has seen larvae of another midge-like dipteran in the Rhyphidae eat moss, but the fragments passed

through the digestive tract intact, with only the epiphytes being digested. (During a conversation with Dr. Kenneth Cummins, we discussed cases where the animal is adapted to eat foods he is unadapted to digest, e. g. Smirnov, 1962. I suspect that many moss feeders including Simulium fit this category.)

Although Percival and Whitehead (1930) report the Tipulid Hexatoma sp. in numbers approaching the chironomids, this genus was rarely represented in the Appalachian collections and was absent in Frost's streams (1942). Another tipulid, Dolichopeza americana, is known from temporarily submerged habitats with Scapania nemorosa (Byers, pers. comm.). But in this study, the larvae occurred among Scapania undulata in Toliver Falls--an area normally under water except for dry summers.

While empids and Atherix variegata are occasional constituents, the only other Diptera of importance are Psychodidae larvae: Pericoma sp. (similar to P. canescens Meig. and P. cognata Eaton). These larvae frequent smaller streams in the tight mats of the Hygroamblystegium group and are almost completely absent among Fontinalis, Scapania, and Hygrohypnum, where they do not have much protection from drifting (Fontinalis), or they would be in rapid water (Scapania and Hygrohypnum).

#### Ephemeroptera (Mayflies)

Whereas some Ephemerella naiads of this study apparently spend their entire nymphal lives in and around mosses, Baetis spp. can only be found in early stages, even during March and July when their maximal sizes occur (Waters, 1966). That Baetis is typically a bottom form frequenting stream drift (Waters, 1961) explains its absence



from the moss. Meanwhile, Paraleptophlebia is a free swimmer, frequently clinging to the surface of the mat in any stage, never abundant, but possibly lost during sampling.

Typically a clinging form, springtime Ephemerella spp. reach extremely high numbers in several Hygroamblystegium streams, but are rare in Scapania and Fontinalis streams (Plates 14 & 15). If any group feeds on mosses, it is probably these herbivores; while the Ephemerella of Linesville Creek feed on algae and detritus (Cummins, unpub. data), Ephemerella ignita composes most of its diet from moss (Percival and Whitehead, 1929). This hypothesis needs to be substantiated by feeding aufwuch-free moss to Ephemerella to determine if the moss is truly the food source.

Several collections of Ephemerella extend the known range of the species:

E. allegheniensis north to Pennsylvania (Saw Creek, 7-29, 65). Allen and Edmunds, 1962

E. catawba north to Maryland (Ginseng Run, 7-9, 65), Hoyes Run (6-11, 65). Allen and Edmunds, 1965

Many of the collections of Ephemerella may be state records, based on the recent examinations of the genus by Allen, Berner, and Edmunds:

E. funeralis in Maryland (Little Bennett Creek, 3-25, 65; Toliver Run, 6-19, 65; 7-9, 65; Ginseng Run, 7-9, 65); in Pennsylvania (Laurel Run, 7-29, 65; Hoch Run, 7-29, 65); in Virginia (Sinking Creek, 3-18, 65). Allen and Edmunds, 1963b

E. attenuata in Maryland (Muddy Creek, 7-9, 65). Allen and Edmunds, 1961

E. cornutella in Maryland (Ginseng Run, not in moss, 7-9, 65). Allen and Edmunds, 1962

E. serratoides in Maryland (Muddy Creek, 7-9, 65); in Pennsylvania (Dingman's Creek, 7-30, 65; Elk Creek, 7-28, 65; Hoch Run, 7-29, 65; Pohopoco Creek, 7-29, 65). Allen and Edmunds, 1963a



E. subvaria (not verified) in Maryland (Toliver Run, 6-11, 65). Allen and Edmunds, 1965

E. temporalis in Maryland (Hoyes Run, 8-25, 65; Little Bennett Creek, 8-20, 65; Muddy Creek, 6-11, 66; Neds Run, 5-4, 65; Toliver Run, 5-4, 65; 6-11, 66); in Pennsylvania (Laurel Run, 7-29, 65; Mud Run, 7-29, 65); in Virginia (Goose Creek, 3-22, 65). Allen and Edmunds, 1963b

Ephemerella invaria might be added for all three states, but these naiads have not been positively separated from E. dorothea.

Although not dominant bryo-insects, Baetisca carolina from Goose Creek (3-22, 65) extends its range northward, while the appearance of Baetisca callosa is a new record for Virginia. (Berner, 1955)

Plecoptera (Stoneflies)

The taxonomy of this group is extremely difficult because the moss inhabitants are quite small, and taxonomic characters are frequently indistinguishable on the early instars. Among the nursery species is Taeniopteryx, which never appears in older stages, while Isoperla bilineata, Nemoura venosa, N. vallicularia, and N. sinuata can be found in all stages. However, the minuteness and large numbers of early instar Nemoura made it impractical to separate the two gilled forms (N. venosa and N. sinuata).

As a generic group, Nemoura shows a slight seasonal increase from March to mid-summer, with the lowest numbers in December. Likewise, Mackereth (1957) shows that Nemoura cambrica Steph. in Westmoreland exhibits a pulse in mid-summer.

The tiny Leuctra reaches a peak in June, but is present year-round, especially in Scapania undulata turfs of Toliver Run, where it exhibits a secondary peak in December. In the study of a stony stream, Mackereth shows that seasonal peaks in numbers of Leuctra differ with the species, so that some species of nymphs are most



abundant in summer, while others are most abundant in winter. The presence of two peaks of abundance in the present study may indicate the presence of two or more species. The appearance of an adult Leuctra in one collection suggests that the naiad may use the moss for emergence. That Nemouridae and Leuctra are among the most common nymphs of mosses has been shown by European workers: Carpenter, 1927; Frost, 1942; Illies, 1952. But in Europe, Amphinemoura and Protonemoura may replace Nemoura.

Peltoperla reaches its highest numbers in Hoyes Run, but in general it occurs in the mats and increases from March through the summer. Pteronarcys is uncommon, as could be expected of so large an insect, but it can be seen clinging to Fontinalis. On one occasion, Pteronarcys biloba was removed and replaced on the streaming Fontinalis dalecarlica. If facing upstream, he entered the streamers; if facing downstream, he clung quietly for several minutes before he was removed and replaced facing upstream, whereupon he immediately entered the streamers. Pteronarcys proteus, a smooth-bodied, smaller nymph, occurs in Hygroamblystegium group mats, but not among streamers of Fontinalis.

While several Perlidae were found in Fontinalis beds, these were never abundant.

#### Trichoptera (Caddisflies)

Within aquatic moss vegetation dwell several caddisfly larvae heretofore undescribed. That these new genera should be found here is not surprising: the habitat is a neglected one in this country; the larvae are tiny; the hydroptilid larva is caseless and looks like an elm mid larva, so that it tends to be rejected in the field by caddis-seekers.

The hydroptilid larva apparently is not indigenous to mosses, for Cummins (pers. comm.) describes a larva matching this one but occurring in the riffles of Linesville Creek (see Cummins, Coffman, and Roff, 1966). Nevertheless, it occurs among bryophytes in Sinking Creek (3-18), Mountain Lake tributary to Sinking Creek (3-18), upstream Ginseng Run (5-4), Mud Run (7-29), Swamp Run (7-29), Laurel Run (7-29), Hoch Run (7-29), and Saw Creek (7-30), but shows no preference for any particular bryophyte species. Wiggins and Flint (pers. comm.) feel that it is unlike any hydroptilid larva known to them, but it must be reared to determine its adult relatives. This larva is small, nearly round in cross section, and bears two posterior hooks; these adaptations would enable it to move easily among the bryophytes.

The other new genus is a brachycentrid, intermediate between Brachycentrus and Micrasema. Like Brachycentrus, it builds a square case, utilizing bryophyte leaves and moss costae, but it lacks the tibial spur of Brachycentrus. On the other hand, the larva resembles Micrasema except for the case, which is round for the known Micrasema. Flint and Wiggins (pers. comm.) hope that it is the undescribed larva of Adicropheles hitcocki Flint, known from Appalachian adults. The new larvae were first collected among moss mats of Pennsylvania streams: Elk Creek (7-28, 65); Swamp Run (7-29, 65); Hoch Run (7-29, 65) under the falls and on the wood of the dam, nestled among Scapania undulata leaves; but they only reached abundance in Saw Creek (7-30, 65), where they occupied mats in mutual exclusion of Micrasema and Brachycentrus when the latter two occurred in Eurynchium riparioides mats. On August 25, 1965, they appeared in collections from Hoyes

Run in Maryland. In all these collections, the larvae were tiny (4-5 mm.) and were thus suited to maneuverability among mosses because of their size.

Since the abundance and kind of caddisflies vary greatly among streams and bryophytes, no one group appears more important than another. As mentioned earlier, Micrasema, Brachycentrus, and the hydroptilids attach their cases to the moss; Paleagapetus celsus utilizes Scapania undulata in its case. This latter hydroptilid larva was first described by Flint in 1962 from Tennessee and North Carolina larvae. Its occurrence in the Deep Creek tributary (larvae: 5-4, 65; 6-11, 66), Toliver Run (larvae: 5-4, 8-25, 12-25, 65; 3-22, 6-11, 66; pupae: 6-19, 65; 6-11, 66), and Swamp Run (larvae: 7-29, 65) apparently record for the first time its northern range. While the larvae of this study build their cases predominantly from Scapania undulata (not S. nemorosa like Flint's specimens), they wander from the Scapania turf to appear occasionally among Fontinalis. Their only occurrence in a non-Scapania stream is with another species of leafy liverwort in Swamp Run. Flint (1962a) states that larvae from Tennessee and North Carolina were collected May 19 to June 9 and adults June 7 to July 1; the remainder of the life cycle is unknown. That pupae appeared only in June for two years of this study indicates this as their principal pupal season in the Garrett County, Maryland area. Furthermore, the reappearance of larvae in late July suggests a short pupal and adult stage unless this insect has a two-year life cycle. But Pennak (1953) points out that it is thought that caddisflies may have either one or two generations per year. Thus, it seems illogical to suggest that so tiny a creature should take two years to develop.

If any group of caddisflies is to be considered most frequent, it must be Rhyacophilidae. Again, the bryophyte provides a nursery, particularly for Rhyacophila torva and the R. invaria group. Adapted for free movement, the case-less Rhyacophila larva has large, free, posterior hooks and no gills. Attesting to the carnivorous habit of the larvae (Percival and Whitehead, 1929), one Rhyacophila nr. carolina larva was preserved with a chironomid larva still in its mouth. Like the Trichoptera in general, the distribution of rhyacophilids in the middle Appalachians is poorly known, and the following apparent state records occur in this study (see Flint, 1962b):

R. fuscula in Maryland (Ginseng Run, 5-4, 65; Hoyes Run, 8-25, 65; Muddy Creek, 8-25, 65; in Pennsylvania (Laurel Run, 7-29, 65; Mud Run, 7-29, 65; Elk Creek, 7-28, 65; Pohopoco Creek, 7-29, 65).

R. torva in Maryland (Hoyes Run, 8-25, 65; 3-22, 6-11, 66; Toliver Run, 3-29, 6-19, 7-9, 8-25, 12-25, 65; Deep Creek tributary, 5-4, 65; Gramlich Run, 6-20, 65; Ginseng, 7-9, 65; Muddy Creek, 8-25, 69; in Pennsylvania (Dingman's Creek, 7-30, 65; Mud Run, 7-29, 65; Laurel Run, 7-29, 65; Hoch Run, 7-29, 65; Elk Creek, 7-28, 65).

R. minora in Maryland (Toliver Run, 5-4, 65).

R. sp. 2 in Maryland (Hoyes Run, 3-22, 66)--see Flint, 1962b.

R. sp. 5 in Maryland (Toliver Run, 6-19, 65)--see Flint, 1962b.

While none of these records extends the known range, they fill some rather obvious gaps in our collecting records.

In addition to the rhyacophilids, Parapsyche apicalis (Hydropsychidae) appears to contribute a state record for Maryland:

Deep Creek tributary (5-4, 65; 6-11, 66); Neds Run (5-4, 65)--see Flint, 1961. The other hydropsychids, except Diplectronea modesta, could not be determined to species, although several Hydropsyche species are present. Larvae of Hydropsyche and Cheumatopsyche

frequently decorate the moss mat with their nets. These variable feeders are known to eat moss (Percival and Whitehead, 1929), algae and animals (Cummins, unpub. data), and one Hydropsyche larva in this study was eating a Baetis sp. naiad when he was preserved.

Another insect in the bryophyte nursery, the Lepidostoma larva seldom occurs in mosses when it passes its early sand case stage, possibly due to the difficulty of maneuvering a bulky case in the bryophyte mat. For this same reason, the large limnephilid Pycnopsyche spp. are rare, but occasionally occur among Fontinalis streamers. But the small limnephilid Neophylax spp. are more frequent among mats, although still not abundant.

Philopotamids may reach high abundance, wherein Dolophiloides distinctus appears in the mats and turfs, while the less frequent Chimarra aterrima seems to be confined to Fontinalis dalecarlica streamers of larger streams.

#### Other Orders

While Orthoptera, Hymenoptera, and Neuroptera were totally absent, early instars of the other aquatic orders were occasional constituents. Tiny nymphs of Hemiptera, such as Microvelia, occur in shallow waters while Little Bennett Creek had nearly mature nymphs of this genus. Early spring found several first instar Odonata--both damsel and dragonflies--in mats of liverworts or mosses, but older instars never appeared. (Large damselfly naiads occur frequently in the large Fontinalis clumps of the Red Cedar River, Ingham Co., Michigan--this author, unpub. data. In these same Red Cedar Fontinalis beds one can find a Nymphalidae caterpillar.) Occasionally young larvae of Megaloptera (Cordulegaster, Nigronia, and Sialis) appear, but these are not regular bryo-community constituents.

## Insect Adaptations to Bryophyte Life

While the morphological adaptations of insects dwelling among aquatic bryophyte vegetation include many that are common among other mountain stream insects, additional restrictions are placed on the bryophyte fauna because of the confined space within these vegetation mats. Steinmann (1907) lists mountain stream adaptations (in Muttkowski, 1929): 1) dorso-ventral flattening; 2) enlargement of adhesive surfaces; 3) small body compass, tendency to dwarfing; 4) attachments--temporary and permanent; 5) by weighting (assumed to mean ballast accumulation); 6) reduction of swimming hairs; 7) respiration--no surface breathers. Among these, several are appropriate to bryophyte inhabitants, while I have added the additional characteristics of generalized feeding (Muttkowski, 1929) and lateral compression.

Dorsal-ventral flattening

Absence of dorsal-ventral flattening exhibited by virtually all bryo-insects is an adaptation to clambering about among the small intra-bryophyte spaces. That is, such mountain stream insects as the flat Heptageniidae or Psephenidae would be inhibited in movement by their broad, but flat, bodies.

Lateral compression

Contrary to dorsal-ventral flattening, lateral compression provides a stream-lined body for ease in movement. While Baetis dwells in mosses only during young stages, it, like larvae of the Hydropsilidae and Elmidae, has easy movement by being laterally compressed and small.



### Enlargement of adhesive surfaces

Any ventral enlargement would be useless to these insects living among tiny branches of bryophytes, and are consequently entirely absent. Thus, we do not find the rapid water, rock-dwelling Blephariceridae and Psephenidae among the bryophytes.

### Small body

Insects dwelling in the bryophytes cover may be early instars that are there for only a transient period of their life cycle or they may be permanent residents. There is some reason to accept that small size has had selective advantage in both cases by permitting ease of movement among the small internal chambers of bryophyte vegetation. This appears especially true for the mayfly Baetis spp., which is free-ranging and a relatively weak swimmer (Waters, 1962), whose early instars increase to about 10 per gram among mosses in the summer, but are virtually absent in later stages when they can be found on the stream bed. Other early instar inhabitants include the crane fly larva Limonia sp., the stonefly Taeniopteryx, the caddisflies Lepidostoma and Neophylax, and occasional Odonata, Hemiptera, and Megaloptera.

Not only is this a nursery for several groups, but the lifelong inhabitants in general are small. The most abundant insects, chironomid larvae, accompany the tiny Empididae and heleid midges. Five genera of microcaddis dwell among bryophytes, while among the beetles, some of the smallest elmids (Promoresia elegans and Optioservus spp.) frequently are among the most numerous. Only on Fontinalis can one find the larger elmids, Stenelmis crenata, or the larger perlid stoneflies, whereas on the mat-forming bryophytes smaller stoneflies such as Isoperla bilineata, Nemoura, and Peltoperla are

common. Only Pteronarcys and Pycnopsyche can be considered large, and Pycnopsyche is rare, while the large Pteronarcys biloba is, like Stenelmis, restricted to Fontinalis dalecarlica.

Its small size is the only obvious adaptation of the new brachycentrid larva, which fashions the bryophyte into a case.

#### Attachments

Whereas the ventral suckers of the mayfly Epeorus are useless, terminal suckers on simuliid larvae enable them to remain on bryophyte surfaces under torrential flow, while a secreted thread permits them to change position without being swept away. Meanwhile, they attach their pupae permanently to the axes and leaves of bryophytes.

Caddisflies frequently attach their cases to the plants: Brachycentrus spp., Micrasema spp., Neotrichia spp., Hydroptila spp., Oxyethira sp.?, Hydropsychidae (a thin net retreat which may incorporate the bryophyte), Philopotamidae (a tubular net case enmeshed with the bryophyte).

Other insects have hooks which permit climbing and clinging: Rhyacophila, elmids larvae and adults, Plecoptera, Ephemerella, Philopotamidae, Chironomidae, and the new hydroptilid larva.

#### Weighting

Like Muttkowski's example, Hydropsychidae build nets in bryophytes, while other Trichoptera are weighted down by heavy cases.

#### Reduction of swimming hairs

Except for a few occasional invaders, swimming hairs are entirely absent on bryophyte insects. Not only are they unnecessary, but they would probably be a detriment to climbing about.

### Respiration

Like the mountain stream insects, few surface breathers live here. Rather, the insects frequently have covered gills (elmid larvae; Ephemerella--with platelike cover gills and covered fibrillar portion), have streamlined gills (Paraleptophlebia), or have no gills (Isoperla, Leuctra, Rhyacophila, Brachycentridae, Hydroptilidae). These adaptations prevent the wear and tear of abrasion as the insect climbs about the bryophyte. The only example of profuse gills is on the hydropsychids, which live a relatively quiet life in a retreat, trapping their food with a net.

### Generalized feeding

Because of the restrictions of the bryophyte habitat, those insects with ability to eat whatever is available would have a selective advantage. Thus, we find adaptations to trap the plankton food supply as it flushes through the bryophyte system: net-building by Hydropsychidae; feathery food-trapping appendages on the Simuliidae. Other insects are able to feed on aufwuchs of the bryophytes, utilizing the bryophyte as a filter for detritus and living organisms. I even suspect the hydropsychids of feeding on aufwuchs, using the moss in place of a net, for I often found the number of larvae far surpassing the number of nets. As already mentioned, some insects probably eat the moss but digest only the aufwuchs. (In this study, I observed no direct evidence of insects eating mosses.) An abundance of aufwuchs is frequently present, especially the diatoms of the genera Fragillaria and Cocconeis, while the desmids of the genera Closterium and Cosmarium are less common (author, unpub. data).

Evidence of carnivory has already been cited, wherein tiny Baetis spp. and Chironomidae feed the larger stoneflies and caddisflies.

## CONCLUSIONS

A survey was made of the insect fauna associated with the stream bryophytes of the central Appalachian Mountain region. This study was planned at the outset as a survey type, and sampling was done by hand grabs in ways that were not compatible with statistical treatment of the data. Streams were sampled at arbitrary times and at varying frequencies. With our primitive state of knowledge of these associations, an extensive first approximation was thought more in order than a detailed local study.

Among the 28 streams studied, three bryophyte-based stream types are apparent: Fontinalis, the Hygroamblystegium group, and Scapania.

A Fontinalis stream is generally larger and has a continuous flow of water sufficient to submerge the moss year-round. Because of its loose nature, Fontinalis has herein been designated a streamer, where one can find the larger of the bryo-insects: Stenelmis crenata, Pteronarcys biloba, and Perlidae. But the smaller insects occur here too, and the greatest variety of insect species is found by comparing all the Fontinalis communities. Nevertheless, when Fontinalis communities of a non-Fontinalis stream are studied, one finds greater variety in insect species among the other bryophytes of that stream, as indicated specifically by Toliver Run. Thus, it appears that only the large (dominant) beds of Fontinalis achieve a great variety of insect species.

The Hygroamblystegium group comprises streams where several bryophytes appear similar and make similar mats. Indeed, their insect faunas are not especially different, nor are the generally narrow,

shallow streams they occupy, so these streams can best be studied as a group. These mats provide the homes for many small insects such as Chironomidae, Simuliidae, Elmidae, Micrasema, Peltopterla, and the new brachycentrid larvae. Like several other caddis larvae, the new brachycentrid larva constructs its case from the moss blades and costae, but the hydroptilid is caseless. Because of the compact internal structure of the Hygroamblystegium group mosses, only small insects frequent them, but the insect variety is usually greater than that found among other bryophytes of the same stream, including Fontinalis.

Scapania streams can hardly be described on the basis of the two Scapania-dominant ones of this study. But a comparison of Scapania with Fontinalis and Sematophyllum in Toliver Run suggests that S. undulata might harbor an insect variety greater than that of other bryophytes, while the number of individuals per gram is also considerably higher. Even in adjacent collections of Scapania and Fontinalis in a dripping waterfall, the latter exhibits fewer individuals, while the folded leaves of Scapania provide a shelter for numerous small insects, protecting them from being dislodged by the flowing water. Larvae of the Rhyacophila carolina group are especially noticeable in Scapania, while they are almost completely absent among other bryophytes. Here also is the larva of Paleagapetus celsus with its Scapania case.

Among the bryophytes in general, the most important group of insects, numberwise, appears to be the Diptera, especially Chironomidae and Simuliidae, while Ephemeroptera, Plecoptera, and Trichoptera are of secondary importance. But even these secondary orders may

exhibit disproportionately high numbers in individual streams or during certain seasons, for example, Plecoptera (Leuctra) in May or Ephemeroptera (Ephemerella) in March.

Seasonal distributions might be inferred from the data on Toller Run and Muddy Creek, with support from other streams having only one collecting date. In general, summer (July and August) collections show the highest numbers of individuals and species, while numbers show a drop in December and reach a low in March and May collections. By June, the numbers appear to be climbing before reaching their peak again in the summer. Exceptions to these patterns are such seasonal insects as Prosimulium spp., which show a peak in December but are absent in mid-summer.

As indicated by the seasonal trends in sizes, kinds, and numbers of insects, one use of the bryophyte appears to be that of a nursery-- a substratum with protective chambers in which tiny insects are harbored and provided with a source of food supplied by the flowing water. Within the mats, protection against predators is effected by the difficulty any large organism would encounter in reaching the inner chambers, although some bryophyte inhabitants (Plecoptera and Trichoptera) prey on smaller insect inhabitants, as noted in this study.

While the bryophyte provides a nursery for some young insects, it also provides a permanent aquatic home for other tiny species. Adaptations to bryophyte living reflect the difficulty of occupying a small space; necessity for compactness. Not only are these insects small; they also may exhibit lateral compression and lack of gills and appendages, while posterior hooks (Rhyacophila) and suction cups

(Simuliidae) protect against being swept away, whereas others use nets (Hydropsychidae) and head fans (Simuliidae) to filter food from the constantly flowing supply. These food filters are located near the flowing water of the bryophyte surface, while the internal chambers of the bryophytes simulate a pool environment.

Because the bryophyte provides its own peculiar conditions for the insects, which are manifest in the afore-mentioned adaptations, the total number of species appears to be somewhat low--150 total for the 28 streams studied. From this low species number, even fewer insects appear to be common ones among the bryophytes. On the basis of frequency, I would consider only about 70 to be true members of the bryo-insect community in these streams, while most collections have about 15-20 species, never exceeding 33.

The comparison of bryophyte communities appears to be an exciting opportunity for comparing a particular stream region in a number of different streams. Based on the low number of insect species found among these streams of the Appalachians, we might expect a higher degree of homogeneity than for most habitat choices which have no biological criteria. As a result of the implications of this study, we can formulate certain basic questions concerning the relationships apparent here:

Why do insect arrays in two species of bryophytes in the same stream differ?

Are the differences related to the morphometry of the bryophyte or to outside influences affecting both the bryophyte and the insects?

What common factors cause species arrays to occur?

How do food species relate to the kinds of insect species?

Is the winter increase in numbers of individuals of certain taxa due to a migration to the bryophyte, to drift caught by the bryophyte, or to other factors?

Are the bryophyte-insect communities continuous or discontinuous with other stream communities?

These are only a beginning of the questions which need to be answered. The problem now remains to find a satisfactory sampling procedure and begin work on why certain relationships appeared in this study.

## TABULAR SUMMARY AND CONCLUSIONS

1. A general survey was made of the insect fauna associated with the stream bryophytes of the central Appalachian Mountain region (Pennsylvania, Maryland, and Virginia). Because this study was intended as a survey, and sampling was done by hand grabs, the data are not amenable to statistical analysis.
2. Twenty-eight streams from the middle Appalachian Mountains were surveyed. Samples were taken from Garrett County, Maryland, streams in March, May, June, summer, and December to show some aspects of the seasonal picture. Other streams were sampled only once.
3. Certain insects are relatively constant members of the collective bryo-community. A few insects appear to relate specifically to certain bryophyte species.
4. These relationships may coincide with case-building materials, type of protection, microhabitat occupied by the bryophyte, or adaptation of the insect for mobility and stability in the bryophyte.
5. Certain bryophytes coincide with certain stream types. Bryophyte to stream relationships may depend on width, depth, speed of flow, permanence, or habitats within the stream. A total of 25 bryophyte species was observed in this study.
6. The number of species of insects collected in aquatic bryophyte vegetation in streams of the middle Appalachians is relatively low and ranges from 1 to 33 in an individual stream with 150 in all.
7. The number of insect individuals per gram (dry weight of bryophyte) varies from .3 to 2887 in this study. The Chironomidae are usually most abundant, while other abundant insects include Promoresia elegans,

the Simulium tuberosum group, the Prosimulium hirtipes group, Leuctra, Nemoura spp., Isoperla bilineata, Ephemerella spp., Baetis, Micrasema spp., and Pericoma.

8. Presence of certain bryophytes might be usable as an indicator of the probable presence of certain kinds of insects.
9. The similarity of insect bryo-communities is high, if compared by bryophyte species groups.
10. The insect bryo-communities of streams with the same bryophyte dominant usually have high community coefficients, but other factors may cause a greater similarity with a stream having different bryophytes.
11. In the bryophyte samples certain insects appear to co-occur, while others appear to be mutually exclusive, but the study was not designed to verify this.
12. Some insects occur with mosses only in young stages.
13. The known ranges of some insects are increased, while other insects are new state records.
14. These collections have brought to light some apparently formerly unknown larvae of insects. These are Trichoptera in the Brachycentridae and Hydroptilidae.

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## APPENDICES

In tables XII-XVI the following symbols represent the stream names, while the Roman numerals are the collection numbers.

|     |                                          |
|-----|------------------------------------------|
| De  | Deep Creek tributary                     |
| Di  | Dingman's Creek                          |
| El  | Elk Creek                                |
| Gi  | Ginseng Run                              |
| Go  | Goose Creek                              |
| Gr  | Gramlich Run                             |
| Hk  | Hoch Run                                 |
| Hy  | Hoyes Run                                |
| Jo  | Johns Creek                              |
| La  | Laurel Run                               |
| LB  | Little Bennett Creek                     |
| Md  | Mud Run                                  |
| My  | Muddy Creek                              |
| Mt  | Mountain Lake tributary to Sinking Creek |
| Ne  | Neds Run                                 |
| Pi  | Pidcock Creek                            |
| Po  | Pohopoco Creek                           |
| Py  | Piney Creek                              |
| Ro  | Rock Castle Creek                        |
| Sa  | Saw Creek                                |
| Sd  | Sideling Hill Creek tributary            |
| Si  | Sinking Creek                            |
| Sw  | Swamp Run                                |
| To  | Toliver Run                              |
| Tot | Toliver Run tributary                    |
| WBe | Seneca Creek tributary at Bell's         |
| WBu | Seneca Creek tributary at Burroughs'     |

TABLE XII. MARCH COUNTS OF INSECTS PER GRAM DRY WEIGHT OF BRYOPHYTE

|                    | Chironomidae L | Chironomidae P | <u>Prosimulium hirtipes</u><br>complex L | <u>Prosimulium hirtipes</u><br>complex P | <u>Nemoura incl.</u><br><u>venosa &amp; sinuata</u> N | <u>Ephemerella invaria</u><br>group N | <u>Isoperla bilineata</u> N | <u>Pericoma</u> L | <u>Bezia</u> group 2 L | <u>Leuctra</u> N |
|--------------------|----------------|----------------|------------------------------------------|------------------------------------------|-------------------------------------------------------|---------------------------------------|-----------------------------|-------------------|------------------------|------------------|
| <u>Fontinalis</u>  |                |                |                                          |                                          |                                                       |                                       |                             |                   |                        |                  |
| <u>dalecarlica</u> |                |                |                                          |                                          |                                                       |                                       |                             |                   |                        |                  |
| ToLXX              | 16.1           |                | 1.4                                      | .2                                       | 3.7                                                   |                                       |                             |                   | .2                     | .6               |
| ToCCCV             | 28.2           |                | 1.2                                      |                                          | 4.6                                                   |                                       |                             |                   |                        | 2.5              |
| ToCCCXI            | 29.8           |                |                                          |                                          | .8                                                    |                                       |                             |                   |                        |                  |
| ToCCCXII           | 11.1           |                |                                          |                                          | 1.1                                                   |                                       |                             |                   |                        |                  |
| DeCCXC             | 4.6            |                | 10.8                                     | .1                                       | 1.3                                                   |                                       | 3.8                         |                   |                        | 2.6              |
| DeCCXCVII          |                |                | 27.7                                     |                                          |                                                       |                                       |                             |                   |                        |                  |
| MyCCXCVIII         | 7.5            |                |                                          |                                          |                                                       |                                       |                             |                   |                        |                  |
| MyCCXCIX           | 5.1            |                |                                          |                                          |                                                       |                                       |                             |                   |                        |                  |
| MyCCC              | 12.6           |                | 1.8                                      | 1.8                                      |                                                       |                                       |                             |                   |                        |                  |
| MyCCCI             | 9.4            |                | 1.7                                      | 6.0                                      |                                                       |                                       | 1.7                         |                   |                        |                  |
| Av.                | 10.8           |                | 6.4                                      | .7                                       | 1.1                                                   |                                       | .8                          |                   |                        | .7               |
| <u>Fontinalis</u>  |                |                |                                          |                                          |                                                       |                                       |                             |                   |                        |                  |
| <u>flaccida</u>    |                |                |                                          |                                          |                                                       |                                       |                             |                   |                        |                  |
| GrLV               | 31.4           |                |                                          |                                          | 5.7                                                   |                                       |                             |                   |                        | 25.7             |
| <u>Hygroambly-</u> |                |                |                                          |                                          |                                                       |                                       |                             |                   |                        |                  |
| <u>stegium</u>     |                |                |                                          |                                          |                                                       |                                       |                             |                   |                        |                  |
| <u>fluviatile</u>  |                |                |                                          |                                          |                                                       |                                       |                             |                   |                        |                  |
| RoXLIV             | 2.5            |                |                                          |                                          |                                                       | 22.5                                  | 12.5                        |                   |                        |                  |
| RoXLII             | 4.5            | .5             | 1.5                                      | .5                                       |                                                       | 57.7                                  | 9.0                         | 3.0               | 1.0                    |                  |
| RoXXXIII           | 4.2            |                |                                          |                                          |                                                       | 34.7                                  |                             |                   | 1.4                    | 8.3              |
| RoXLIII            | 100.0          | 5.3            |                                          |                                          |                                                       | 5.3                                   | 5.3                         | 5.3               |                        |                  |
| RoXLV              | 144.1          |                |                                          |                                          |                                                       | 20.6                                  | 29.4                        | 182.4             | 2.9                    |                  |
| RoXXXVI            | 4.3            |                | .9                                       |                                          |                                                       | 60.9                                  | 16.5                        | 4.3               |                        |                  |
| RoXXXIX            | NC             |                |                                          |                                          |                                                       | 75.9                                  | 9.0                         | .8                |                        |                  |
| RoXL               | 15.5           |                | 9.7                                      |                                          |                                                       | 24.2                                  | 2.9                         | 7.8               |                        |                  |
| RoXXXIV            | 10.1           |                | .3                                       |                                          |                                                       | 59.1                                  | 8.7                         |                   |                        |                  |
| RoXXXV             | 23.3           |                | .3                                       |                                          |                                                       | 52.1                                  | 14.4                        | 2.6               | .7                     |                  |
| HoCCCXIV           | 15.5           |                | 6.7                                      | .5                                       | 2.6                                                   | 5.7                                   | 5.7                         | .5                |                        |                  |
| HoCCCXV            | 43.0           |                | 27.9                                     |                                          | 1.2                                                   | 12.8                                  | 15.1                        | 45.3              |                        |                  |
| HoCCCXVI           | 39.3           |                | 9.3                                      |                                          | .9                                                    | 8.4                                   | 6.5                         | 8.4               |                        |                  |
| HoCCCXVII          | 83.8           |                | 4.8                                      |                                          | 3.8                                                   | 15.2                                  | 8.6                         | 19.0              | 1.0                    | 2.9              |
| HoCCCXVIII         | 41.2           |                | 21.2                                     |                                          | 3.5                                                   | 5.9                                   | 2.4                         | 35.3              |                        |                  |
| DeCCXCIII          |                |                |                                          |                                          | 1.2                                                   |                                       |                             |                   |                        |                  |
| GrLXIII            | .6             |                |                                          |                                          |                                                       | .3                                    | .3                          | .6                |                        |                  |
| SiXXIV             | 16.7           |                |                                          |                                          |                                                       | 1.0                                   |                             |                   |                        | 1.0              |
| LXXLVI             | 13.0           |                |                                          |                                          | 1.0                                                   |                                       |                             | .2                | .8                     |                  |

[illegible]

|                                                                     | <u>Chironomidae L</u> | <u>Chironomidae P</u> | <u>Prosimulium hirtipes</u><br><u>complex L</u> | <u>Prosimulium hirtipes</u><br><u>complex P</u> | <u>Nemoura incl.</u><br><u>venosa &amp; sinuata N</u> | <u>Ephemerella invaria</u><br><u>group N</u> | <u>Isoperla bilineata N</u> | <u>Pericoma L</u> | <u>Bezzia group 2 L</u> | <u>Leuctra N</u> |
|---------------------------------------------------------------------|-----------------------|-----------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------------|----------------------------------------------|-----------------------------|-------------------|-------------------------|------------------|
| <u>Grimmia</u><br><u>alpicola</u> var. <u>rivularis</u><br>SdLXXVII | 81.2                  |                       | .6                                              |                                                 | 2.4                                                   | .6                                           | 4.2                         |                   |                         |                  |
| <u>Hygrohypnum</u><br><u>luridum</u><br>DeCCXCI                     | 19.5                  |                       | 48.8                                            |                                                 | 2.4                                                   |                                              |                             |                   |                         | 12.2             |
| DeCCXCII                                                            | 17.0                  |                       | 38.3                                            |                                                 | 2.1                                                   |                                              |                             |                   |                         |                  |
| DeCCXCVI                                                            | 1.2                   |                       | 43.2                                            |                                                 | 2.5                                                   |                                              |                             |                   | 1.2                     |                  |
| Undetermined<br>DeCCXCV                                             | 8.8                   |                       | 1.8                                             |                                                 |                                                       |                                              |                             |                   |                         |                  |
| <u>Sciaromium</u><br><u>lescurii</u><br>LBXLVIII                    | 23.4                  |                       |                                                 |                                                 | .5                                                    |                                              |                             |                   | 1.1                     |                  |
| <u>Senatophyllum</u><br><u>marylandicum</u><br>ToLXXIII             | .7                    |                       |                                                 |                                                 | .1                                                    |                                              |                             |                   | .4                      |                  |
| ToLXXIV                                                             | 1.4                   |                       |                                                 |                                                 |                                                       |                                              |                             |                   |                         |                  |
| Undetermined<br>ToCCCVI                                             | 19.5                  |                       |                                                 |                                                 | 8.5                                                   |                                              |                             |                   | .6                      | 2.4              |
| <u>Scapania</u><br><u>undulata</u><br>ToLXXI                        | 52.7                  |                       | 2.0                                             |                                                 | 18.8                                                  |                                              |                             |                   |                         | 28.2             |
| ToCCCI                                                              | 47.5                  |                       | 4.0                                             |                                                 | 5.0                                                   |                                              |                             |                   |                         |                  |
| ToCCCI                                                              | 37.0                  | .6                    | 13.0                                            |                                                 | 19.8                                                  |                                              |                             |                   |                         | 3.1              |
| ToCCCI                                                              | 25.0                  |                       | 65.0                                            |                                                 | 5.0                                                   |                                              |                             |                   |                         | 8.3              |
| ToCCCVII                                                            | 20.3                  |                       | 32.9                                            |                                                 | 8.9                                                   |                                              |                             |                   |                         | 5.1              |
| ToCCCVIII                                                           | 34.2                  |                       | 51.5                                            |                                                 | 9.2                                                   |                                              |                             |                   | 4.9                     | 12.0             |
| ToCCCI                                                              | 19.7                  |                       | 15.4                                            |                                                 | 6.0                                                   |                                              |                             |                   | .9                      | 6.8              |
| ToCCCX                                                              | 20.2                  |                       | 25.7                                            |                                                 | 2.8                                                   |                                              |                             | .9                |                         | 6.4              |
| ToCCCXIII                                                           | 9.2                   |                       | 5.1                                             |                                                 | .9                                                    |                                              |                             |                   | .9                      |                  |
| DeCCXCIV                                                            | 9.7                   | 1.0                   | 38.8                                            |                                                 | 1.0                                                   |                                              | 2.9                         | 1.0               |                         | 2.9              |
| Av.                                                                 | 19.8                  | .5                    | 31.4                                            |                                                 | 4.8                                                   |                                              | 1.5                         | .6                | .4                      | 5.4              |
| Undetermined<br>GrLXII                                              | 3.4                   |                       |                                                 |                                                 |                                                       | 1.7                                          |                             |                   |                         | 1.0              |

|                                                           | <u>Simulium tuberosum</u><br>complex L | <u>Empid</u> sp. 1 L | <u>Nemoura vallicularia</u> N | <u>Promoresia elegans</u> L | <u>Promoresia elegans</u> A | <u>Hydroptila</u> L | <u>Peltoperla</u> N | <u>Dasyhelea</u> sp. 2 L | <u>Cheumatopsyche</u> L | <u>Rhyacophila carolina</u> L |
|-----------------------------------------------------------|----------------------------------------|----------------------|-------------------------------|-----------------------------|-----------------------------|---------------------|---------------------|--------------------------|-------------------------|-------------------------------|
| <u>Fontinalis</u><br><u>dalecarlica</u>                   |                                        |                      |                               |                             |                             |                     |                     |                          |                         |                               |
| ToLXX                                                     |                                        |                      | .2                            |                             |                             |                     |                     |                          |                         |                               |
| ToCCCV                                                    |                                        | .3                   | .3                            |                             |                             |                     |                     |                          |                         |                               |
| ToCCCXI                                                   |                                        |                      | 2.5                           |                             |                             |                     |                     |                          |                         |                               |
| ToCCCXII                                                  | 1.1                                    |                      |                               |                             |                             |                     |                     |                          |                         |                               |
| DeCCXC                                                    |                                        |                      |                               |                             |                             | .1                  | .6                  |                          |                         |                               |
| DeCCXCVII                                                 | 2.3                                    |                      | 2.9                           |                             |                             |                     |                     |                          |                         |                               |
| MyCCXCVIII                                                | 4.5                                    |                      |                               | 3.0                         |                             |                     |                     |                          |                         |                               |
| MyCCXCIX                                                  |                                        |                      |                               | 1.1                         |                             |                     |                     |                          |                         |                               |
| MyCCC                                                     | 5.4                                    |                      |                               | 2.7                         |                             |                     |                     |                          |                         |                               |
| MyCCCI                                                    | 15.4                                   | .9                   |                               | 6.8                         |                             |                     |                     |                          | .9                      |                               |
| Av.                                                       | 2.6                                    | .1                   | .8                            | 1.1                         |                             | .01                 | .1                  |                          | .1                      |                               |
| <u>Fontinalis</u><br><u>flaccida</u>                      |                                        |                      |                               |                             |                             |                     |                     |                          |                         |                               |
| GrLV                                                      |                                        |                      |                               |                             |                             |                     |                     |                          |                         |                               |
| <u>Hygroambly-</u><br><u>stegium</u><br><u>fluviatile</u> |                                        |                      |                               |                             |                             |                     |                     |                          |                         |                               |
| RoXLIV                                                    |                                        |                      |                               |                             |                             | 5.0                 |                     |                          |                         |                               |
| RoXLII                                                    |                                        | .5                   | .5                            |                             |                             | 3.5                 |                     |                          |                         |                               |
| RoXXXIII                                                  |                                        |                      |                               |                             |                             |                     |                     |                          | 2.8                     |                               |
| RoXLIII                                                   |                                        | 5.3                  |                               |                             |                             |                     |                     |                          |                         |                               |
| RoXLV                                                     |                                        |                      |                               |                             |                             |                     |                     |                          |                         |                               |
| RoXXXVI                                                   |                                        |                      |                               |                             |                             | 8.7                 |                     |                          | 1.7                     |                               |
| RoXXXIX                                                   |                                        |                      | .8                            |                             |                             |                     |                     |                          | 2.3                     |                               |
| RoXL                                                      |                                        |                      |                               |                             |                             | 1.0                 |                     |                          | 2.9                     | 1.0                           |
| RoXXXIV                                                   |                                        | .3                   |                               | .3                          |                             | 2.0                 |                     |                          | 3.2                     |                               |
| RoXXXV                                                    |                                        |                      |                               |                             |                             | .3                  |                     | 3.0                      | .3                      |                               |
| HoCCCXIV                                                  | 1.6                                    | .5                   | 117.1                         | 39.1                        |                             |                     | 2.6                 |                          |                         |                               |
| HoCCCXV                                                   | 1.2                                    | 1.2                  | 137.2                         | 1.2                         |                             |                     | 3.5                 |                          |                         |                               |
| HoCCCXVI                                                  |                                        |                      | 222.4                         | 4.7                         |                             |                     | 1.9                 |                          |                         |                               |
| HoCCCXVII                                                 |                                        |                      | 3.0                           |                             |                             |                     | 1.9                 | 1.0                      |                         |                               |
| HoCCCXVIII                                                | 1.2                                    |                      | 82.4                          | 2.4                         |                             | 1.2                 | 4.7                 |                          |                         |                               |
| DeCCXCIII                                                 |                                        |                      | 1.2                           |                             |                             |                     |                     |                          |                         |                               |
| GrLXIII                                                   |                                        |                      |                               |                             |                             |                     |                     | .3                       |                         |                               |
| SiXXIV                                                    |                                        |                      |                               |                             |                             |                     |                     |                          |                         |                               |
| LbXLVI                                                    |                                        | .2                   |                               |                             |                             |                     |                     |                          |                         |                               |









|                                                                                                                                                              |                                                   |                                            |  |                                        |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|--------------------------------------------|--|----------------------------------------|--|
|                                                                                                                                                              | <u>Tipula collaris</u> L                          |                                            |  |                                        |  |
|                                                                                                                                                              | <u>Bezzia</u> sp. 1 L                             |                                            |  |                                        |  |
|                                                                                                                                                              | <u>Baetisca callosa</u> N                         |                                            |  |                                        |  |
|                                                                                                                                                              | <u>Diplectrona modesta</u> L                      |                                            |  |                                        |  |
|                                                                                                                                                              | <u>Maggot</u> L                                   |                                            |  |                                        |  |
|                                                                                                                                                              | <u>Palaepagetus celus</u> L                       |                                            |  |                                        |  |
|                                                                                                                                                              | <u>Limnophorus</u> L                              |                                            |  |                                        |  |
|                                                                                                                                                              | <u>Limnophila</u> L                               |                                            |  |                                        |  |
|                                                                                                                                                              | <u>Hydroptilid</u> gen. 1 L                       |                                            |  |                                        |  |
|                                                                                                                                                              | <u>Prosimulium magnum</u> L                       |                                            |  |                                        |  |
| <u>Grimmia</u><br><u>alpicola</u> var. <u>rivularis</u><br>SdLXXVII                                                                                          |                                                   |                                            |  | .6                                     |  |
| <u>Hygrohypnum</u><br><u>luridum</u><br>DeCCXCI<br>DeCCXCII<br>DeCCXCVI                                                                                      |                                                   |                                            |  |                                        |  |
| Undetermined                                                                                                                                                 |                                                   |                                            |  |                                        |  |
| DeCCXCV                                                                                                                                                      |                                                   |                                            |  |                                        |  |
| <u>Sciaromium</u><br><u>lescurei</u><br>LBXLVIII                                                                                                             | 3.9                                               |                                            |  | 1.1                                    |  |
| <u>Sematophyllum</u><br><u>marylandicum</u><br>ToLXXIII<br>ToLXXIV                                                                                           |                                                   |                                            |  |                                        |  |
| Undetermined                                                                                                                                                 |                                                   |                                            |  |                                        |  |
| ToCCCVI                                                                                                                                                      |                                                   |                                            |  |                                        |  |
| <u>Scapania</u><br><u>undulata</u><br>ToLXXI<br>ToCCCII<br>ToCCCIII<br>ToCCCIV<br>ToCCCVII<br>ToCCCVIII<br>ToCCCIX<br>ToCCCX<br>ToCCCXIII<br>DeCCXCIV<br>Av. | 1.7<br><br><br><br><br><br><br><br><br>1.9<br>1.1 | 1.3<br><br><br><br><br><br><br><br><br>.05 |  | 1.3<br>1.6<br>2.6<br>4.6<br><br><br>.5 |  |
| Undetermined<br>GrLXII                                                                                                                                       |                                                   |                                            |  |                                        |  |

|                                                           | <u>Rhyacophila invaria</u> L | <u>Rhyacophila torva</u> L | <u>Lepidostoma</u> L | <u>Atherix variegata</u> L | <u>Dasyhelea</u> sp. 1 L | <u>Hydropsyche</u> L | <u>Micrasema</u> (tiny L) | <u>Optioservus</u> L | <u>Cnephia mutata</u> L | <u>Cnephia mutata</u> P |
|-----------------------------------------------------------|------------------------------|----------------------------|----------------------|----------------------------|--------------------------|----------------------|---------------------------|----------------------|-------------------------|-------------------------|
| <u>Fontinalis</u><br><u>dalecarlica</u>                   |                              |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| ToLXX                                                     |                              |                            |                      |                            |                          |                      |                           |                      |                         | .2                      |
| ToCCCV                                                    |                              |                            |                      |                            |                          |                      |                           |                      | .6                      |                         |
| ToCCCXI                                                   |                              |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| ToCCCXII                                                  |                              |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| DeCCXC                                                    | .1                           |                            | .1                   |                            |                          |                      |                           |                      | .1                      |                         |
| DeCCXCVII                                                 |                              |                            |                      | .6                         |                          |                      |                           |                      |                         |                         |
| MyCCXCVIII                                                |                              |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| MyCCXCIX                                                  |                              |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| MyCCC                                                     |                              |                            |                      |                            |                          | .9                   |                           |                      |                         |                         |
| MyCCCI                                                    |                              |                            |                      |                            |                          | .9                   |                           |                      |                         |                         |
| Av.                                                       | .02                          |                            | .02                  | .1                         |                          | .2                   |                           |                      | .1                      | .02                     |
| <u>Fontinalis</u><br><u>flaccida</u>                      |                              |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| GrLV                                                      |                              |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| <u>Hygroambly-</u><br><u>stegium</u><br><u>fluviatile</u> |                              |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| RoXLIV                                                    |                              |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| RoXLII                                                    |                              |                            |                      |                            | 1.5                      | .5                   |                           |                      |                         |                         |
| RoXXXIII                                                  |                              |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| RoXLIII                                                   |                              |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| RoXLV                                                     |                              | 5.9                        |                      |                            | 2.6                      |                      |                           |                      |                         |                         |
| RoXXXVI                                                   |                              |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| RoXXXIX                                                   |                              |                            |                      |                            |                          |                      |                           | 1.5                  |                         |                         |
| RoXL                                                      |                              |                            |                      |                            |                          | 1.0                  |                           |                      |                         |                         |
| RoXXXIV                                                   |                              |                            | .3                   | .3                         | .6                       |                      |                           | .3                   |                         |                         |
| RoXXXV                                                    |                              |                            | .3                   |                            |                          |                      |                           | .3                   |                         |                         |
| HoCCCXIV                                                  | .5                           |                            |                      | 1.6                        |                          |                      | .5                        | .5                   |                         |                         |
| HoCCCXV                                                   | 1.2                          |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| HoCCCXVI                                                  |                              |                            |                      |                            |                          |                      | 24.3                      |                      |                         |                         |
| HoCCCXVII                                                 |                              |                            |                      |                            |                          |                      |                           | 1.0                  |                         |                         |
| HoCCCXVIII                                                | 1.2                          |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| DeCCXCIII                                                 |                              |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| GrLXIII                                                   |                              |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| SiXXIV                                                    |                              |                            |                      |                            |                          |                      |                           |                      |                         |                         |
| LbXLVI                                                    |                              |                            |                      |                            | .2                       |                      |                           | .2                   |                         |                         |





|                    | <u>Pteronarcys</u> <u>protens</u> N | <u>Pycnopsycha</u> <u>scabripennis</u> L | <u>Baetis</u> spp. N |
|--------------------|-------------------------------------|------------------------------------------|----------------------|
| <u>Fontinalis</u>  |                                     |                                          |                      |
| <u>dalecarlica</u> |                                     |                                          |                      |
| ToLXX              |                                     |                                          |                      |
| ToCCCV             |                                     |                                          |                      |
| ToCCCXI            |                                     |                                          |                      |
| ToCCCXII           |                                     |                                          |                      |
| DeCCXC             |                                     | .1                                       |                      |
| DeCCXCVII          |                                     |                                          |                      |
| MyCCXCVIII         |                                     |                                          |                      |
| MyCCXCIX           |                                     |                                          |                      |
| MyCCC              |                                     |                                          |                      |
| MyCCCI             |                                     |                                          |                      |
| Av.                |                                     | .02                                      |                      |
| <u>Fontinalis</u>  |                                     |                                          |                      |
| <u>flaccida</u>    |                                     |                                          |                      |
| GrLV               |                                     |                                          |                      |
| <u>Hygroambly-</u> |                                     |                                          |                      |
| <u>stegium</u>     |                                     |                                          |                      |
| <u>fluviatile</u>  |                                     |                                          |                      |
| RoXLIV             |                                     |                                          |                      |
| RoXLII             |                                     |                                          |                      |
| RoXXXIII           |                                     |                                          |                      |
| RoXLIII            |                                     |                                          |                      |
| RoXLV              |                                     |                                          |                      |
| RoXXXVI            |                                     |                                          |                      |
| RoXXXIX            |                                     | .8                                       |                      |
| RoXL               |                                     |                                          |                      |
| RoXXXIV            |                                     |                                          |                      |
| RoXXXV             |                                     |                                          |                      |
| HoCCCXIV           | 2.1                                 |                                          | .5                   |
| HoCCCXV            |                                     |                                          | 2.3                  |
| HoCCCXVI           | .9                                  | .9                                       | 1.9                  |
| HoCCCXVII          |                                     |                                          |                      |
| HoCCCXVIII         | 3.5                                 |                                          |                      |
| DeCCXCIII          |                                     |                                          |                      |
| GrLXIII            |                                     |                                          |                      |
| SiXXIV             |                                     |                                          |                      |
| LbXLVI             |                                     |                                          |                      |

|                                                           | <u>Pteronarcys proteus</u> N | <u>Pycnopsyche scabripennis</u> L | <u>Baetis</u> spp. N |
|-----------------------------------------------------------|------------------------------|-----------------------------------|----------------------|
| <u>Hygroambly-</u><br><u>stegium</u><br><u>fluviatile</u> |                              |                                   |                      |
| SBuLI                                                     |                              |                                   |                      |
| SBuLII                                                    |                              |                                   |                      |
| SiMtXXVIII                                                |                              |                                   |                      |
| SiMtXXX                                                   |                              |                                   |                      |
| SiMtXXXI                                                  |                              |                                   |                      |
| Av.                                                       | .2                           | .04                               | .1                   |
| <u>Hygroambly-</u><br><u>stegium</u><br><u>tenax</u>      |                              |                                   |                      |
| SiXXV                                                     |                              |                                   |                      |
| SiXXVI                                                    |                              |                                   |                      |
| SiXXIII                                                   |                              |                                   |                      |
| <u>Amblystegium</u><br><u>varium</u>                      |                              |                                   |                      |
| SiXXII                                                    |                              |                                   |                      |
| <u>Eurynchium</u><br><u>riparioides</u>                   |                              |                                   |                      |
| GrLXIX                                                    |                              |                                   |                      |
| RoXXXII                                                   |                              |                                   |                      |
| <u>Brachythecium</u><br><u>plumosum</u>                   |                              |                                   |                      |
| RoXXXVIII                                                 |                              |                                   |                      |
| GrLVII                                                    |                              |                                   |                      |
| GrLIX                                                     |                              |                                   |                      |
| SdLXXV                                                    |                              |                                   |                      |
| SdLXXVI                                                   |                              |                                   |                      |
| <u>Brachythecium</u><br><u>rivulare</u>                   |                              |                                   |                      |
| GrLIV                                                     |                              |                                   |                      |
| SiMtXXVII                                                 |                              |                                   |                      |
| RoXXXVII                                                  |                              |                                   |                      |
| <u>Bryhnia</u><br><u>novae-angliae</u>                    |                              |                                   |                      |
| SBeLIII                                                   |                              |                                   |                      |

Pteronarcys protens NPycnopeyche scabripennis LBaetis app. N

Grimmia  
alpicola var. rivularis  
 SdLXXVII

Hygrohypnum  
luridum  
 DeCCXCI  
 DeCCXCII  
 DeCCXCVI

Undetermined

DeCCXCV

Sciaromium  
lescurei  
 LBXLVIII

Sematophyllum  
marylandicum  
 ToLXXIII  
 ToLXXIV

Undetermined

ToCCCVI

Scapania  
undulata

ToLXXI .3  
 ToCCCI  
 ToCCCI  
 ToCCCI  
 ToCCCVII  
 ToCCCVIII  
 ToCCCI  
 ToCCCI  
 ToCCCI  
 ToCCCI  
 DeCCXCIV

Av. .02

Undetermined  
 GrLXII

TABLE XIII. MAY COUNTS OF INSECTS PER GRAM DRY WEIGHT OF BRYOPHYTE

|                      | <u>Chironomidae L</u> | <u>Chironomidae P</u> | <u>Simulium tuberosum</u><br><u>complex L</u> | <u>Simulium tuberosum</u><br><u>complex P</u> | <u>Nemoura incl.</u><br><u>venosa &amp; sinuata N</u> | <u>Leuctra N</u> | <u>Prosimulium hirtipes</u><br><u>complex L</u> | <u>Prosimulium hirtipes</u><br><u>complex P</u> | <u>Ephemerella invaria</u><br><u>group N</u> | <u>Isoperla bilineata N</u> |
|----------------------|-----------------------|-----------------------|-----------------------------------------------|-----------------------------------------------|-------------------------------------------------------|------------------|-------------------------------------------------|-------------------------------------------------|----------------------------------------------|-----------------------------|
| <u>Fontinalis</u>    |                       |                       |                                               |                                               |                                                       |                  |                                                 |                                                 |                                              |                             |
| <u>dalecarlica</u>   |                       |                       |                                               |                                               |                                                       |                  |                                                 |                                                 |                                              |                             |
| DeCVI                | 6.6                   |                       | 1.2                                           |                                               | 18.8                                                  | 6.2              | 18.5                                            | 8.0                                             |                                              | .1                          |
| ToCVIIB              | 4.3                   |                       | 82.7                                          |                                               | 16.0                                                  | 8.4              | 9.5                                             | 4.6                                             |                                              |                             |
| ToCIX                | 3.0                   |                       | 1.1                                           |                                               | 1.5                                                   | .5               | 1.1                                             | 4.2                                             | .2                                           |                             |
| MyCXII               | 5.2                   |                       | 25.1                                          |                                               |                                                       |                  |                                                 |                                                 |                                              | 1.5                         |
| NeCXIII              | 173.8                 | .4                    | 1.5                                           |                                               | 1.5                                                   | 1.5              |                                                 |                                                 |                                              |                             |
| PyCXVI               | 384.9                 | 1.0                   |                                               |                                               | 11.5                                                  | .5               |                                                 |                                                 | 3.1                                          |                             |
| Av.                  | 114.8                 | .3                    | 13.9                                          |                                               | 8.1                                                   | 2.5              | 4.7                                             | 2.5                                             | .6                                           | .3                          |
| <u>Hygroambly-</u>   |                       |                       |                                               |                                               |                                                       |                  |                                                 |                                                 |                                              |                             |
| <u>stegium</u>       |                       |                       |                                               |                                               |                                                       |                  |                                                 |                                                 |                                              |                             |
| <u>fluviatile</u>    |                       |                       |                                               |                                               |                                                       |                  |                                                 |                                                 |                                              |                             |
| PyCXVII              | 37.3                  | 1.3                   | .1                                            |                                               | 9.4                                                   | .3               |                                                 |                                                 | 2.0                                          |                             |
| DeCV                 | 16.5                  |                       | 1.2                                           |                                               | 10.9                                                  | 3.7              | 21.8                                            | 2.5                                             |                                              |                             |
| G1CXV                | 10.6                  |                       | .1                                            |                                               | 1.2                                                   | .7               |                                                 | .4                                              | 31.6                                         | 2.7                         |
| G1CXIV               | 10.4                  | .9                    | 9.4                                           | .1                                            | 6.0                                                   |                  | .2                                              | 1.4                                             | 31.8                                         | 4.3                         |
| GrLXXXIV             | 144.4                 |                       | 40.0                                          |                                               | 6.7                                                   |                  |                                                 |                                                 |                                              | 6.7                         |
| Av.                  | 52.1                  | .5                    | 11.5                                          | .01                                           | 7.6                                                   | 1.1              | 5.4                                             | .9                                              | 8.4                                          | 2.6                         |
| <u>Eurynchium</u>    |                       |                       |                                               |                                               |                                                       |                  |                                                 |                                                 |                                              |                             |
| <u>riparioides</u>   |                       |                       |                                               |                                               |                                                       |                  |                                                 |                                                 |                                              |                             |
| GrLXXXV              | 65.6                  |                       | 4.0                                           |                                               |                                                       |                  |                                                 | .8                                              | 14.4                                         | 1.6                         |
| GrLXXXVI             | 29.2                  |                       | 18.3                                          |                                               |                                                       |                  |                                                 | .8                                              | 4.2                                          | 7.5                         |
| GrXCIX               | 317.2                 | .5                    | 43.4                                          | .5                                            | 3.6                                                   | 2.3              |                                                 | 1.4                                             | 11.4                                         | 5.9                         |
| Av.                  | 137.3                 | .2                    | 21.9                                          | .2                                            | 1.2                                                   | .8               |                                                 | 1.0                                             | 10.0                                         | 5.0                         |
| <u>Brachythecium</u> |                       |                       |                                               |                                               |                                                       |                  |                                                 |                                                 |                                              |                             |
| <u>plumosum</u>      |                       |                       |                                               |                                               |                                                       |                  |                                                 |                                                 |                                              |                             |
| GrCII                | NC                    |                       |                                               |                                               | 1.0                                                   | 1.7              |                                                 |                                                 | 6.3                                          | .7                          |
| <u>Sciaromium</u>    |                       |                       |                                               |                                               |                                                       |                  |                                                 |                                                 |                                              |                             |
| <u>lescurii</u>      |                       |                       |                                               |                                               |                                                       |                  |                                                 |                                                 |                                              |                             |
| TotCXI               | 4.7                   | .4                    | .8                                            |                                               | 4.7                                                   | .1               | 1.5                                             | 1.0                                             | 7.9                                          | .7                          |
| LBLXXIX              | 63.9                  |                       |                                               |                                               | 2.1                                                   |                  |                                                 |                                                 |                                              |                             |
| LBLXXX               | 52.6                  | 2.6                   | 4.8                                           |                                               | 4.7                                                   |                  |                                                 |                                                 | .4                                           |                             |
| Av.                  | 31.5                  | .9                    | 1.6                                           |                                               | 4.1                                                   | .05              | .8                                              | .5                                              | 4.1                                          | .4                          |
| <u>Scapania</u>      |                       |                       |                                               |                                               |                                                       |                  |                                                 |                                                 |                                              |                             |
| <u>undulata</u>      |                       |                       |                                               |                                               |                                                       |                  |                                                 |                                                 |                                              |                             |
| DeCIV                | 5.4                   | .3                    | .5                                            |                                               | 10.8                                                  | 2.1              |                                                 | 3.6                                             |                                              | .3                          |
| ToCVIIA              | 3.5                   | .2                    | 8.9                                           |                                               | 3.9                                                   | 5.2              | 9.4                                             | 2.2                                             |                                              |                             |
| ToCVIII              | 8.7                   |                       | 68.6                                          |                                               | 10.3                                                  | 31.9             | 30.5                                            | 23.1                                            | .2                                           |                             |
| Av.                  | 5.8                   | .2                    | 19.5                                          |                                               | 9.0                                                   | 10.3             | 10.0                                            | 8.2                                             | .05                                          | .2                          |

|                      | <u>Peltoberla</u> N | <u>Lepidostoma</u> L | <u>Protopresia</u> elegans L | <u>Promoresia</u> elegans A | <u>Atherix</u> variegata L | <u>Phryacophila</u> invaria L | <u>Cnephia</u> mutata L | <u>Cnephia</u> mutata P | <u>Pericoma</u> L | <u>Bezzia</u> group 2 L |
|----------------------|---------------------|----------------------|------------------------------|-----------------------------|----------------------------|-------------------------------|-------------------------|-------------------------|-------------------|-------------------------|
| <u>Fontinalis</u>    |                     |                      |                              |                             |                            |                               |                         |                         |                   |                         |
| <u>dalecarlica</u>   |                     |                      |                              |                             |                            |                               |                         |                         |                   |                         |
| DeCVI                | 2.7                 | .1                   |                              |                             |                            |                               |                         | .1                      |                   |                         |
| ToCVIIB              | .3                  | .3                   | 1.2                          |                             | .3                         |                               |                         | .3                      |                   | .3                      |
| ToCIX                | .5                  | .2                   |                              |                             |                            |                               |                         | .2                      |                   |                         |
| MyCXII               |                     |                      | 29.9                         | .7                          |                            |                               |                         |                         |                   |                         |
| NeCXIII              |                     | .6                   |                              |                             |                            |                               | .2                      |                         |                   |                         |
| PyCXVI               |                     |                      |                              |                             | .2                         |                               | 4.1                     |                         | 2.9               |                         |
| Av.                  | .6                  | .2                   | 6.1                          | .1                          | .1                         |                               | .9                      | .08                     | .6                | .03                     |
| <u>Hygroambly-</u>   |                     |                      |                              |                             |                            |                               |                         |                         |                   |                         |
| <u>stegium</u>       |                     |                      |                              |                             |                            |                               |                         |                         |                   |                         |
| <u>fluviatile</u>    |                     |                      |                              |                             |                            |                               |                         |                         |                   |                         |
| PyCXVII              |                     |                      | .7                           | .7                          | .7                         |                               |                         |                         | 19.6              |                         |
| DeCV                 | 1.7                 |                      |                              |                             | .3                         |                               |                         |                         |                   |                         |
| GiCXV                | 2.5                 | .9                   | 1.1                          | .1                          | .6                         |                               |                         |                         | 1.5               | .1                      |
| GiCXIV               | .1                  | .1                   | 3.1                          | 1.3                         | .2                         |                               |                         |                         | 3.6               | .5                      |
| GrLXXXIV             |                     |                      |                              |                             |                            |                               |                         |                         |                   |                         |
| Av.                  | .7                  | .1                   | .7                           | .3                          | .3                         |                               |                         |                         | 6.2               | .08                     |
| <u>Eurynchium</u>    |                     |                      |                              |                             |                            |                               |                         |                         |                   |                         |
| <u>riparioides</u>   |                     |                      |                              |                             |                            |                               |                         |                         |                   |                         |
| GrLXXXV              |                     |                      |                              |                             |                            |                               |                         |                         |                   |                         |
| GrLXXXVI             |                     |                      |                              |                             |                            | 1.7                           |                         |                         |                   |                         |
| GrXCIX               |                     |                      |                              |                             |                            | .5                            |                         |                         |                   |                         |
| Av.                  |                     |                      |                              |                             |                            | .7                            |                         |                         |                   |                         |
| <u>Brachythecium</u> |                     |                      |                              |                             |                            |                               |                         |                         |                   |                         |
| <u>plumosum</u>      |                     |                      |                              |                             |                            |                               |                         |                         |                   |                         |
| GrCII                |                     |                      |                              |                             |                            | .7                            |                         |                         |                   |                         |
| <u>Sciaromium</u>    |                     |                      |                              |                             |                            |                               |                         |                         |                   |                         |
| <u>lescurii</u>      |                     |                      |                              |                             |                            |                               |                         |                         |                   |                         |
| TotCXI               | .9                  |                      | 5.9                          | .6                          | 1.0                        | .3                            |                         |                         | 2.6               |                         |
| LBLXXIX              |                     | 1.0                  |                              |                             |                            |                               |                         |                         | 3.1               | 4.1                     |
| LBLXXX               |                     |                      |                              |                             |                            | .4                            |                         |                         | 3.0               | 7.0                     |
| Av.                  | .3                  | .3                   | 2.0                          | .2                          | .3                         | .2                            |                         |                         | 2.9               | 2.8                     |
| <u>Scapania</u>      |                     |                      |                              |                             |                            |                               |                         |                         |                   |                         |
| <u>undulata</u>      |                     |                      |                              |                             |                            |                               |                         |                         |                   |                         |
| DeCIV                | 3.6                 | .3                   |                              |                             | 1.3                        |                               |                         |                         |                   |                         |
| ToCVIIA              |                     | .5                   | .1                           |                             |                            | .2                            |                         | .1                      |                   | .1                      |
| ToCVIII              |                     |                      | .2                           | .2                          |                            | 8.3                           |                         | .2                      |                   |                         |
| Av.                  | .9                  | .2                   | .08                          | .05                         | .4                         | 2.8                           |                         | .1                      |                   | .03                     |

|                      | <u>Dasyhelea</u> sp. 2 L | <u>Empid</u> sp. 1 L | <u>Nemoura</u> <u>vallicularia</u> N | <u>Neophylax</u> <u>concinus</u> L | <u>Optioservus</u> L | <u>Paleagapetus</u> <u>celsus</u> L | <u>Hydroptila</u> L | <u>Hydroptila</u> P | <u>Bezzia</u> sp. 1 | <u>Diplectrona</u> <u>modesta</u> L |
|----------------------|--------------------------|----------------------|--------------------------------------|------------------------------------|----------------------|-------------------------------------|---------------------|---------------------|---------------------|-------------------------------------|
| <u>Fontinalis</u>    |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| <u>dalecarlica</u>   |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| DeCVI                |                          |                      | .8                                   |                                    |                      |                                     | .3                  |                     |                     |                                     |
| ToCVIIB              |                          |                      | .8                                   | .3                                 |                      | .3                                  |                     |                     |                     | 1.1                                 |
| ToCIX                |                          |                      |                                      |                                    |                      |                                     | .3                  |                     |                     |                                     |
| MyCXII               |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     | .2                                  |
| NeCXIII              |                          |                      |                                      | .4                                 | .2                   |                                     |                     |                     |                     |                                     |
| PyCXVI               | .2                       | 1.0                  |                                      | 2.4                                | .2                   |                                     |                     |                     |                     |                                     |
| Av.                  | .04                      | .2                   | .2                                   | .6                                 | .1                   | .03                                 | .06                 |                     |                     | .15                                 |
| <u>Hygroambly-</u>   |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| <u>stegium</u>       |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| <u>fluviatile</u>    |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| PyCXVII              | .4                       | .9                   | .1                                   | 2.2                                | .9                   |                                     | .9                  |                     | .3                  |                                     |
| DeCV                 |                          |                      | 1.4                                  |                                    |                      |                                     |                     |                     | .2                  |                                     |
| GiCXV                |                          | .2                   |                                      | .1                                 | 1.9                  |                                     |                     |                     | .1                  | .2                                  |
| GiCXIV               |                          | 1.3                  |                                      |                                    | .1                   |                                     |                     |                     |                     | .4                                  |
| GrLXXIV              | 11.1                     |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| Av.                  | 2.3                      | .5                   | .3                                   | .5                                 | .6                   |                                     | .3                  |                     | .09                 | .1                                  |
| <u>Eurynchium</u>    |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| <u>riparioides</u>   |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| GrLXXXV              |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| GrLXXXVI             |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| GrXCIX               | .9                       |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| Av.                  | .3                       |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| <u>Brachythecium</u> |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| <u>plumosum</u>      |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| GrCII                | 15.6                     |                      |                                      |                                    | .3                   |                                     | .3                  |                     |                     |                                     |
| <u>Sciaromium</u>    |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| <u>lescurii</u>      |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| TotCXI               |                          | .6                   |                                      |                                    | .1                   |                                     |                     |                     |                     |                                     |
| LBLXXIX              |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| LBLXXX               |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| Av.                  |                          | .2                   |                                      |                                    | .03                  |                                     |                     |                     |                     |                                     |
| <u>Scapania</u>      |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| <u>undulata</u>      |                          |                      |                                      |                                    |                      |                                     |                     |                     |                     |                                     |
| DeCIV                |                          |                      | 2.3                                  |                                    |                      | .5                                  |                     |                     |                     |                                     |
| ToCVIIA              |                          |                      |                                      |                                    |                      | .1                                  |                     |                     |                     |                                     |
| ToCVIII              |                          |                      |                                      |                                    |                      | .2                                  |                     |                     | .4                  |                                     |
| Av.                  |                          |                      | .6                                   |                                    |                      | .2                                  |                     |                     | .1                  |                                     |



|                      | <u>Cheumatopsyche L</u> | <u>Optioservus sp. 1 A</u> | <u>Optioservus sp. 2 A</u> | <u>Paraleptophlebia N</u> | <u>Rhyacophila torva L</u> | <u>Baetis N</u> | <u>Empid sp. 2 L</u> |
|----------------------|-------------------------|----------------------------|----------------------------|---------------------------|----------------------------|-----------------|----------------------|
| <u>Fontinalis</u>    |                         |                            |                            |                           |                            |                 |                      |
| <u>dalecarlica</u>   |                         |                            |                            |                           |                            |                 |                      |
| DeCVI                |                         |                            |                            |                           | .3                         |                 |                      |
| ToCVIIB              |                         |                            |                            |                           |                            |                 |                      |
| ToCIX                |                         |                            | .2                         |                           |                            |                 |                      |
| MyCXII               | .2                      |                            |                            |                           |                            |                 | .7                   |
| NeCXIII              |                         |                            |                            |                           |                            | .2              |                      |
| PyCXVI               |                         |                            |                            |                           |                            | 1.2             |                      |
| Av.                  | .04                     |                            | .02                        |                           | .06                        | .3              | .1                   |
| <u>Hygroambly-</u>   |                         |                            |                            |                           |                            |                 |                      |
| <u>stegium</u>       |                         |                            |                            |                           |                            |                 |                      |
| <u>fluviatile</u>    |                         |                            |                            |                           |                            |                 |                      |
| PyCXVII              | .1                      |                            |                            | .1                        |                            | .6              |                      |
| DeCV                 |                         |                            | .2                         |                           | .6                         |                 |                      |
| GiCXV                | .5                      |                            |                            | .7                        |                            | .2              |                      |
| GiCXIV               | .1                      |                            |                            |                           |                            | .5              | .3                   |
| GrLXXXIV             |                         |                            |                            |                           |                            |                 |                      |
| Av.                  | .1                      |                            | .05                        | .1                        | .2                         | .3              | .03                  |
| <u>Eurynchium</u>    |                         |                            |                            |                           |                            |                 |                      |
| <u>riparioides</u>   |                         |                            |                            |                           |                            |                 |                      |
| GrLXXXV              |                         |                            |                            |                           |                            |                 |                      |
| GrLXXXVI             |                         |                            |                            |                           |                            |                 | .8                   |
| GrXCIX               |                         |                            |                            |                           |                            | .5              |                      |
| Av.                  |                         |                            |                            |                           |                            | .2              | .3                   |
| <u>Brachythecium</u> |                         |                            |                            |                           |                            |                 |                      |
| <u>plumosum</u>      |                         |                            |                            |                           |                            |                 |                      |
| GrCII                |                         |                            |                            |                           |                            |                 |                      |
| <u>Sciaromium</u>    |                         |                            |                            |                           |                            |                 |                      |
| <u>lascurii</u>      |                         |                            |                            |                           |                            |                 |                      |
| TotCXI               |                         |                            |                            |                           |                            |                 |                      |
| LBXXXIX              |                         |                            |                            |                           |                            |                 |                      |
| LBXXX                |                         |                            |                            | 2.2                       |                            |                 |                      |
| Av.                  |                         |                            |                            | .6                        |                            |                 |                      |
| <u>Scapania</u>      |                         |                            |                            |                           |                            |                 |                      |
| <u>undulata</u>      |                         |                            |                            |                           |                            |                 |                      |
| DeCIV                |                         |                            |                            |                           | .3                         |                 |                      |
| ToCVIIA              |                         |                            |                            |                           |                            |                 |                      |
| ToCVIII              |                         |                            | .2                         |                           |                            |                 |                      |
| Av.                  |                         |                            | .05                        |                           | .15                        |                 |                      |



TABLE XIV. JUNE COUNTS OF INSECTS PER GRAM DRY WEIGHT OF BRYOPHYTE

|                    | Chironomidae L | Chironomidae P | Leuctra N | Simulium tuberosum<br>complex L | Simulium tuberosum<br>complex P | Nemoura incl.<br>venosa & sinuata N | Promoresia elegans L | Promoresia elegans A | Baetis spp. N | Isoperla bilineata N |
|--------------------|----------------|----------------|-----------|---------------------------------|---------------------------------|-------------------------------------|----------------------|----------------------|---------------|----------------------|
| <u>Fontinalis</u>  |                |                |           |                                 |                                 |                                     |                      |                      |               |                      |
| <u>dalecarlica</u> |                |                |           |                                 |                                 |                                     |                      |                      |               |                      |
| ToCXXVI            | 220.4          | 1.2            | .6        |                                 |                                 | .6                                  |                      |                      |               |                      |
| ToCXXVIII          | 101.4          | .6             | 7.7       |                                 |                                 |                                     | 1.5                  | .2                   |               |                      |
| ToCCCXXXVIII       | 23.5           |                | .4        | 4.6                             | 1.5                             | .4                                  |                      |                      |               |                      |
| ToCCCXXXIX         | 31.7           |                | 1.8       | 4.1                             |                                 | .9                                  | 3.7                  |                      |               |                      |
| ToCCCXL            | 79.2           |                | .9        | 15.1                            | .9                              |                                     | 1.8                  | 2.7                  |               |                      |
| ToCCCXLI           | 51.3           | .4             | 16.0      | 8.0                             | .8                              | 6.5                                 | 1.5                  |                      | .4            |                      |
| MyCCCXLV           | 92.1           |                |           | 2.8                             | .5                              |                                     | 2.8                  | .5                   | 13.2          | .5                   |
| MyCCCXLVI          | 9.6            |                |           | 6.7                             |                                 |                                     | 16.3                 | 4.4                  | 3.7           | 1.5                  |
| MyCCCXLVII         | 16.2           |                | 1.6       | 2.2                             | 1.6                             |                                     | 19.4                 | 11.3                 | 5.7           | .5                   |
| MyCCCXLVIII        | 59.8           |                |           |                                 |                                 |                                     | 4.3                  | 1.2                  | 7.9           |                      |
| MyCCCXLIX          | 13.0           |                |           | .8                              | .2                              |                                     | 6.5                  | 2.5                  | 16.0          | .6                   |
| MyCCCL             | 28.6           |                |           | 1.6                             |                                 |                                     | 9.0                  | 10.6                 | 6.4           | .5                   |
| MyCCCLI            | 36.5           |                | .8        |                                 | 2.1                             |                                     | 7.0                  | .8                   | 2.5           | .8                   |
| MyCCCLII           | 46.9           |                |           | .7                              | 2.0                             |                                     | 4.1                  | 2.7                  | 3.4           |                      |
| DeCCCLIII          | 144.9          |                | 11.9      |                                 |                                 | 10.5                                |                      |                      |               | 2.1                  |
| DeCCCLV            | 50.4           |                | 3.4       |                                 |                                 | 14.8                                |                      |                      |               |                      |
| Av.                | 73.3           | .03            | 4.2       | 2.4                             | .4                              | 4.7                                 | 3.8                  | 1.6                  | 3.5           | .5                   |
| <u>Hygroambly-</u> |                |                |           |                                 |                                 |                                     |                      |                      |               |                      |
| <u>stegium</u>     |                |                |           |                                 |                                 |                                     |                      |                      |               |                      |
| <u>fluviatile</u>  |                |                |           |                                 |                                 |                                     |                      |                      |               |                      |
| HoCCCXXV           | 147.0          | 1.1            | 6.4       |                                 | .6                              | 5.9                                 | 24.4                 | 6.2                  | 7.9           | 11.2                 |
| HoCCCXXXVI         | 211.2          |                |           | .5                              |                                 |                                     | 199.2                | 16.8                 | 1.0           | 3.8                  |
| HoCCCXXXVII        | 96.9           | .7             | .3        | .3                              | .7                              | 1.7                                 | 94.9                 | 5.4                  | 3.4           | 4.8                  |
| Av.                | 151.7          | .6             | 2.2       | .3                              | .4                              | 2.5                                 | 106.1                | 9.5                  | 4.1           | 6.6                  |
| <u>Eurynchium</u>  |                |                |           |                                 |                                 |                                     |                      |                      |               |                      |
| <u>riparioides</u> |                |                |           |                                 |                                 |                                     |                      |                      |               |                      |
| GrCXXX             | 122.8          |                | 1.0       | 1.0?                            |                                 |                                     |                      |                      |               | 4.0                  |
| GrCXXXII           | 1282.1         |                |           |                                 |                                 |                                     |                      |                      |               | 10.3                 |
| Av.                | 702.4          |                | .5        | .5                              |                                 |                                     |                      |                      |               | 7.2                  |
| <u>Sciaromium</u>  |                |                |           |                                 |                                 |                                     |                      |                      |               |                      |
| <u>leacurii</u>    |                |                |           |                                 |                                 |                                     |                      |                      |               |                      |
| LFCXL              | 176.2          |                | 4.8       |                                 |                                 |                                     |                      |                      |               |                      |

|                 | <u>Chironomidae L</u> | <u>Chironomidae P</u> | <u>Leuctra N</u> | <u>Simulium tuberosum<br/>complex L</u> | <u>Simulium tuberosum<br/>complex P</u> | <u>Nemoura incl.<br/>venosa &amp; sinuata N</u> | <u>Promoresia elegans L</u> | <u>Promoresia elegans A</u> | <u>Baetis spp. N</u> | <u>Isoperla bilineata N</u> |
|-----------------|-----------------------|-----------------------|------------------|-----------------------------------------|-----------------------------------------|-------------------------------------------------|-----------------------------|-----------------------------|----------------------|-----------------------------|
| <u>Scapania</u> |                       |                       |                  |                                         |                                         |                                                 |                             |                             |                      |                             |
| <u>undulata</u> |                       |                       |                  |                                         |                                         |                                                 |                             |                             |                      |                             |
| ToCXXI          | 310.8                 | 1.6                   | 71.7             | 62.9                                    | 2.4                                     | 24.3                                            |                             | .4                          |                      |                             |
| ToCXXII         | 305.6                 | 2.1                   | 11.7             | .7                                      |                                         | .7                                              |                             |                             | .7                   |                             |
| ToCXXIII        | 172.7                 | 3.2                   | 103.2            | 130.0                                   | 8.6                                     | 21.9                                            |                             |                             |                      |                             |
| ToCXXIV         | 141.2                 |                       | 76.5             | 579.4                                   | 94.1                                    | 38.2                                            |                             |                             |                      |                             |
| ToCXXV          | 64.9                  | 1.6                   | 69.5             | 230.5                                   | 4.7                                     | 17.6                                            |                             | .4                          |                      |                             |
| ToCXXVII        | 151.6                 |                       | 151.6            | 106.3                                   | 18.4                                    | 22.6                                            | 1.1                         |                             |                      |                             |
| ToCCCXLI        | 87.7                  | 3.1                   | 8.2              | 156.1                                   | 15.3                                    | 3.1                                             | 3.1                         | 1.0                         |                      |                             |
| ToCCCXLIII      | 37.0                  |                       | 79.5             | 136.7                                   | 4.5                                     | 16.5                                            | .5                          |                             |                      |                             |
| ToCCCXLIV       | 45.1                  | .6                    | 25.0             | 57.3                                    | 4.9                                     | 11.0                                            | 2.4                         |                             |                      |                             |
| DeCCCLIV        | 153.6                 |                       | 36.0             |                                         |                                         | 33.6                                            |                             |                             |                      | 3.6                         |
| DeCCCLVI        | 18.7                  |                       | 14.0             |                                         |                                         | 9.4                                             |                             |                             |                      |                             |
| Av.             | 116.2                 | .6                    | 45.7             | 81.6                                    | 8.9                                     | 19.4                                            | .4                          | .1                          | .05                  | .3                          |



|                    | <u>Peltoberla N</u> | <u>Empid sp. 1 L</u> | <u>Rhyacophila carolina L</u> | <u>Prosimulium hirtipes complex L</u> | <u>Prosimulium hirtipes complex P</u> | <u>Ephemerella invaria group N</u> | <u>Taeniopteryx N</u> | <u>Lepidostoma L</u> | <u>Atherix variegata L</u> | <u>Optioservus sp. 2 A</u> |
|--------------------|---------------------|----------------------|-------------------------------|---------------------------------------|---------------------------------------|------------------------------------|-----------------------|----------------------|----------------------------|----------------------------|
| <u>Fontinalis</u>  |                     |                      |                               |                                       |                                       |                                    |                       |                      |                            |                            |
| <u>dalecarlica</u> |                     |                      |                               |                                       |                                       |                                    |                       |                      |                            |                            |
| ToCXXVI            | .6                  | .6                   |                               |                                       |                                       |                                    |                       |                      |                            |                            |
| ToCXXVIII          |                     |                      |                               |                                       |                                       |                                    | .4                    | .2P                  |                            |                            |
| ToCCCXXVIII        |                     |                      |                               |                                       |                                       |                                    | 1.1                   |                      |                            |                            |
| ToCCCXXIX          |                     |                      |                               |                                       |                                       |                                    | 1.8                   |                      |                            |                            |
| ToCCCL             |                     |                      |                               |                                       |                                       | .9                                 | 3.6                   |                      |                            |                            |
| ToCCCLI            |                     |                      |                               | .8                                    |                                       |                                    | 5.3                   | .4                   | .4                         |                            |
| MyCCCLV            |                     |                      |                               |                                       |                                       | .5                                 |                       |                      |                            |                            |
| MyCCCLXVI          |                     |                      |                               |                                       |                                       |                                    |                       |                      |                            |                            |
| MyCCCLXVII         |                     |                      |                               |                                       |                                       |                                    |                       |                      |                            |                            |
| MyCCCLXVIII        |                     |                      |                               |                                       |                                       |                                    |                       |                      |                            |                            |
| MyCCCLIX           |                     |                      |                               |                                       |                                       | .2                                 |                       |                      |                            |                            |
| MyCCCL             |                     |                      |                               |                                       |                                       |                                    |                       |                      |                            | .5                         |
| MyCCCLI            |                     |                      |                               |                                       |                                       |                                    |                       |                      | .4                         |                            |
| MyCCCLII           |                     |                      |                               |                                       |                                       |                                    |                       |                      |                            |                            |
| DeCCCLIII          | 7.7                 |                      | .7                            | 11.9                                  | 8.4                                   | .7                                 |                       | .7                   |                            |                            |
| DeCCCLV            | 3.1                 |                      |                               |                                       | 1.1                                   | 1.6                                |                       | .8                   |                            |                            |
| Av.                | 1.8                 |                      | .12                           | 2.0                                   | 1.8                                   | .5                                 |                       | .3                   | .05                        | .02                        |
| <u>Hygroambly-</u> |                     |                      |                               |                                       |                                       |                                    |                       |                      |                            |                            |
| <u>stegium</u>     |                     |                      |                               |                                       |                                       |                                    |                       |                      |                            |                            |
| <u>fluviatile</u>  |                     |                      |                               |                                       |                                       |                                    |                       |                      |                            |                            |
| HoCCCXXV           | 23.2                |                      |                               |                                       |                                       |                                    |                       |                      | .6                         |                            |
| HoCCCXXVI          | 13.9                |                      | .5                            |                                       |                                       |                                    |                       |                      |                            |                            |
| HoCCCXXVII         | 17.0                |                      |                               |                                       |                                       |                                    |                       |                      | 1.0                        |                            |
| Av.                | 18.0                |                      | .2                            |                                       |                                       |                                    |                       |                      | .5                         |                            |
| <u>Eurynchium</u>  |                     |                      |                               |                                       |                                       |                                    |                       |                      |                            |                            |
| <u>riparioides</u> |                     |                      |                               |                                       |                                       |                                    |                       |                      |                            |                            |
| GrCXXX             |                     | 1.0                  |                               |                                       |                                       | 1.0                                |                       | 1.0                  |                            |                            |
| GrCXXXII           |                     | .9                   |                               |                                       |                                       |                                    |                       |                      | 3.4                        |                            |
| Av.                |                     | 1.0                  |                               |                                       |                                       | .5                                 |                       | .5                   | 1.7                        |                            |
| <u>Sciaronium</u>  |                     |                      |                               |                                       |                                       |                                    |                       |                      |                            |                            |
| <u>lescurii</u>    |                     |                      |                               |                                       |                                       |                                    |                       |                      |                            |                            |
| LBCXL              |                     | 2.4                  |                               |                                       |                                       |                                    |                       | 2.4                  |                            |                            |

|                 | <u>Peltoberla N</u> | <u>Empid sp. 1 L</u> | <u>Rhyacophila carolina L</u> | <u>Prosimulium hirtipes<br/>complex L</u> | <u>Prosimulium hirtipes<br/>complex P</u> | <u>Ephemerella invaria<br/>group N</u> | <u>Taeniopteryx N</u> | <u>Lepidostoma L</u> | <u>Atherix variegata L</u> | <u>Optioservus sp. 2 A</u> |
|-----------------|---------------------|----------------------|-------------------------------|-------------------------------------------|-------------------------------------------|----------------------------------------|-----------------------|----------------------|----------------------------|----------------------------|
| <u>Scapania</u> |                     |                      |                               |                                           |                                           |                                        |                       |                      |                            |                            |
| <u>undulata</u> |                     |                      |                               |                                           |                                           |                                        |                       |                      |                            |                            |
| ToCXXI          | .8                  | 4.8                  |                               |                                           |                                           |                                        |                       |                      |                            |                            |
| ToCXXII         |                     |                      |                               |                                           |                                           |                                        |                       | .7                   |                            |                            |
| ToCXXIII        | 1.1                 | 1.1                  | 2.1                           |                                           | .5                                        |                                        |                       |                      |                            |                            |
| ToCXXIV         |                     | 2.9                  | 5.9                           |                                           | 2.9                                       |                                        |                       |                      |                            |                            |
| ToCXXV          | 1.2                 | .8                   | 2.0                           | .4                                        |                                           |                                        |                       |                      |                            | .4                         |
| ToCXXVII        | 6.3                 | 1.1                  | 3.2                           |                                           |                                           |                                        |                       |                      |                            |                            |
| ToCCCXLII       |                     |                      | 1.0                           |                                           | 2.0                                       | 1.0                                    | 6.1                   |                      |                            | 1.0                        |
| ToCCCXLIII      |                     |                      | 4.5                           |                                           | 1.5                                       |                                        |                       |                      |                            |                            |
| ToCCCXLIV       | 1.2                 | .6                   | .6                            |                                           | 1.8                                       |                                        | .6                    |                      |                            | .6                         |
| DeCCCLIV        | 7.2                 |                      | 1.2                           | 4.8                                       | 6.0                                       | 2.4                                    | 6.0                   |                      | 1.2                        | 1.2                        |
| DeCCCLVI        | 1.6                 |                      |                               | 1.6                                       | 1.6                                       | .8                                     |                       |                      |                            |                            |
| Av.             | 2.8                 | 5.6                  | 1.4                           | 1.6                                       | 2.4                                       | .4                                     | 1.2                   | .1                   | .1                         | .4                         |

|                    | <u>Micrasema</u> sp. 2 L | <u>Micrasema</u> sp. 3 L | <u>Dolophiloides distinctus</u> L | <u>Cnephia mutata</u> L | <u>Paleagapetus celsus</u> L | <u>Bezria</u> group 2 L | <u>Paraleptophlebia</u> N | <u>Pericoma</u> L | <u>Rhyacophila torva</u> L | <u>Stenelmia crenata</u> A |
|--------------------|--------------------------|--------------------------|-----------------------------------|-------------------------|------------------------------|-------------------------|---------------------------|-------------------|----------------------------|----------------------------|
| <u>Fontinalis</u>  |                          |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| <u>dalecarlica</u> |                          |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| ToCXXVI            |                          |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| ToCXXVIII          |                          |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| ToCCCXXXVIII       |                          |                          |                                   | 1.1P                    |                              |                         |                           |                   |                            |                            |
| ToCCCXXXIX         |                          |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| ToCCCXL            |                          |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| ToCCCXLI           |                          |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| MyCCCXLV           | 1.9                      |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| MyCCCXLVI          |                          | 1.5                      |                                   |                         |                              |                         |                           |                   |                            | .7                         |
| MyCCCXLVII         | 3.8                      | 1.1                      |                                   |                         |                              |                         |                           |                   |                            | .5                         |
| MyCCCXLVIII        |                          | .6                       |                                   |                         |                              | .6P                     |                           |                   |                            |                            |
| MyCCCXLIX          | 2.1                      |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| MyCCCL             |                          | .5                       |                                   |                         |                              |                         |                           |                   |                            | .5                         |
| MyCCCLI            | .8                       |                          |                                   |                         |                              |                         |                           |                   |                            | .8                         |
| MyCCCLII           | .7                       |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| DeCCCLIII          |                          |                          | 1.4                               | 17.5                    |                              | .7                      |                           |                   |                            |                            |
| DeCCCLV            |                          |                          |                                   | .3                      |                              |                         |                           |                   |                            |                            |
| Av.                | .4                       | .2                       | .2                                | 3.0                     |                              | .1                      |                           |                   |                            | .1                         |
| <u>Hygroambly-</u> |                          |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| <u>stegium</u>     |                          |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| <u>fluviatile</u>  |                          |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| HoCCCXXV           |                          |                          | 2.8                               |                         |                              |                         | 2.0                       | 1.1               |                            |                            |
| HoCCCXXVI          |                          |                          | .5                                |                         |                              |                         |                           | 1.0               |                            |                            |
| HoCCCXXVII         |                          | .3                       | .3                                |                         |                              |                         | 1.0                       | 4.1               | .3                         |                            |
| Av.                |                          | .1                       | 1.2                               |                         |                              |                         | .1                        | 2.1               | .1                         |                            |
| <u>Eurynchium</u>  |                          |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| <u>riparioides</u> |                          |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| GrCXXX             |                          |                          |                                   |                         |                              | 3.0                     | 1.0                       | 1.0               |                            |                            |
| GrCXXXII           |                          |                          |                                   |                         |                              |                         |                           |                   | 1.7                        |                            |
| Av.                |                          |                          |                                   |                         |                              | 1.5                     | .5                        | .5                | .9                         |                            |
| <u>Sciaromium</u>  |                          |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| <u>lescurei</u>    |                          |                          |                                   |                         |                              |                         |                           |                   |                            |                            |
| LBCXL              |                          |                          | 9.5                               |                         |                              | 4.8                     | 7.1                       |                   |                            |                            |

|                 |  | <u>Micrasema</u> sp. 2 L | <u>Micrasema</u> sp. 3 L | <u>Dolophiloides distinctus</u> L | <u>Cnephia</u> <u>mutata</u> L | <u>Paleagapetus celsus</u> L | <u>Bezzia</u> group 2 L | <u>Paraleptophlebia</u> N | <u>Pericoma</u> L | <u>Rhyacophila torva</u> L | <u>Stenelmis crenata</u> A |
|-----------------|--|--------------------------|--------------------------|-----------------------------------|--------------------------------|------------------------------|-------------------------|---------------------------|-------------------|----------------------------|----------------------------|
| <u>Scapania</u> |  |                          |                          |                                   |                                |                              |                         |                           |                   |                            |                            |
| <u>undulata</u> |  |                          |                          |                                   |                                |                              |                         |                           |                   |                            |                            |
| ToCXXI          |  |                          |                          |                                   |                                |                              |                         |                           |                   |                            |                            |
| ToCXXII         |  |                          |                          |                                   |                                |                              |                         |                           |                   |                            |                            |
| ToCXXIII        |  |                          |                          |                                   |                                | 1.6                          |                         |                           |                   |                            |                            |
| ToCXXIV         |  |                          |                          |                                   |                                |                              |                         |                           |                   |                            |                            |
| ToCXXV          |  |                          |                          |                                   |                                |                              |                         |                           |                   |                            |                            |
| ToCXXVII        |  |                          |                          |                                   |                                |                              |                         |                           |                   | 2.6                        |                            |
| ToCCCXLI I      |  |                          |                          |                                   |                                | 1.0                          |                         |                           |                   | 2.0                        |                            |
| ToCCCXLIII      |  |                          |                          |                                   |                                | .5 <sup>P</sup>              | .5                      |                           |                   |                            |                            |
| ToCCCXLIV       |  |                          |                          |                                   |                                | .6 <sup>P</sup>              |                         |                           |                   |                            |                            |
| DeCCCLIV        |  |                          |                          |                                   | 4.8                            | 1.2                          |                         |                           |                   |                            |                            |
| DeCCCLVI        |  |                          |                          |                                   | 3.1                            | .8                           |                         |                           |                   |                            |                            |
| Av.             |  |                          |                          |                                   | 2.0                            | .7                           | .03                     |                           |                   | .4                         |                            |

|                    | <u>Simulium barnassum</u> L | <u>Hydropsychid</u> (tiny L) | <u>Hydroptila</u> L | <u>Rhyacophila invaria</u> L | <u>Optioservus</u> sp. 1 A | <u>Pteronarcys proteus</u> N |
|--------------------|-----------------------------|------------------------------|---------------------|------------------------------|----------------------------|------------------------------|
| <u>Fontinalis</u>  |                             |                              |                     |                              |                            |                              |
| <u>dalecarlica</u> |                             |                              |                     |                              |                            |                              |
| ToCX XVI           |                             |                              | .6                  |                              |                            |                              |
| ToCX XVIII         |                             |                              | .2P                 |                              |                            |                              |
| ToCCCXXXVIII       |                             |                              |                     |                              |                            |                              |
| ToCCCXXXIX         |                             |                              |                     |                              |                            |                              |
| ToCCCXL            |                             |                              |                     |                              |                            |                              |
| ToCCCXLI           |                             |                              |                     |                              |                            |                              |
| MyCCCXLV           |                             |                              |                     |                              |                            |                              |
| MyCCCXLVI          | .7                          |                              |                     |                              |                            |                              |
| MyCCCXLVII         | 3.2                         |                              |                     |                              |                            |                              |
| MyCCCXLVIII        |                             |                              |                     |                              |                            |                              |
| MyCCCXLIX          |                             |                              | .2                  |                              |                            |                              |
| MyCCCL             |                             |                              | 1.1                 |                              |                            |                              |
| MyCCCLI            | 22.2                        |                              |                     |                              |                            |                              |
| MyCCCLII           | 22.4                        |                              |                     |                              |                            |                              |
| DeCCCLIII          |                             |                              |                     |                              |                            |                              |
| DeCCCLV            |                             |                              |                     |                              |                            |                              |
| Av.                | 2.0                         |                              | .1                  |                              |                            |                              |
| <u>Hygroambly-</u> |                             |                              |                     |                              |                            |                              |
| <u>stegium</u>     |                             |                              |                     |                              |                            |                              |
| <u>fluviatile</u>  |                             |                              |                     |                              |                            |                              |
| HoCCCXXXV          |                             |                              |                     |                              | 1.4                        |                              |
| HoCCCXXXVI         |                             |                              |                     |                              | .5                         |                              |
| HoCCCXXXVII        |                             |                              |                     |                              | .7                         |                              |
| Av.                |                             |                              |                     |                              | .9                         |                              |
| <u>Eurynchium</u>  |                             |                              |                     |                              |                            |                              |
| <u>riparioides</u> |                             |                              |                     |                              |                            |                              |
| GrCXXX             |                             |                              | 1.0                 |                              |                            |                              |
| GrCXXXII           |                             |                              | .9                  |                              |                            |                              |
| Av.                |                             |                              | 1.0                 |                              |                            |                              |
| <u>Sciaromium</u>  |                             |                              |                     |                              |                            |                              |
| <u>lescurii</u>    |                             |                              |                     |                              |                            |                              |
| LBCXL              |                             |                              |                     |                              |                            |                              |

|                 | <u>Simulium parnassum</u> L | <u>Hydropsychid</u> (tiny L) | <u>Hydroptila</u> L | <u>Rhyacophila invaria</u> L | <u>Optioservus</u> sp. 1 A | <u>Pteronarcys proteus</u> N |
|-----------------|-----------------------------|------------------------------|---------------------|------------------------------|----------------------------|------------------------------|
| <u>Scapania</u> |                             |                              |                     |                              |                            |                              |
| <u>undulata</u> |                             |                              |                     |                              |                            |                              |
| ToCXXI          |                             | 2.0                          |                     | 1.6                          |                            |                              |
| ToCXXII         |                             |                              |                     |                              |                            |                              |
| ToCXXIII        |                             | 4.8                          |                     | .5P                          |                            |                              |
| ToCXXIV         | NC                          |                              |                     |                              |                            |                              |
| ToCXXV          | NC                          | .4                           |                     |                              | .8                         |                              |
| ToCXXVII        | NC                          | 1.6                          |                     |                              |                            |                              |
| ToCCCXLII       | NC                          |                              |                     |                              | 2.0                        |                              |
| ToCCCXLIII      | NC                          |                              |                     |                              |                            |                              |
| ToCCCXLIV       | NC                          |                              |                     |                              | .6                         |                              |
| DeCCCLIV        |                             |                              |                     |                              |                            |                              |
| DeCCCLVI        |                             |                              |                     |                              |                            |                              |
| Av.             |                             | .5                           |                     | .1                           | .2                         |                              |

TABLE XV. SUMMER COUNTS OF INSECTS PER GRAM DRY WEIGHT OF BRYOPHYTE

| Bryophyte<br>Collection<br>Number | <u>Chironomidae L</u> | <u>Chironomidae P</u> | <u>Promoresia elegans L</u> | <u>Promoresia elegans A</u> | <u>Simulium tuberosum<br/>complex L</u> | <u>Simulium tuberosum<br/>complex P</u> | <u>Isoperla bilineata N</u> | <u>Empid sp. L L</u> | <u>Hydropsyche L</u> | <u>Hydropsychids<br/>(tiny L)</u> |
|-----------------------------------|-----------------------|-----------------------|-----------------------------|-----------------------------|-----------------------------------------|-----------------------------------------|-----------------------------|----------------------|----------------------|-----------------------------------|
| <u>Fontinalis<br/>dalecarlica</u> |                       |                       |                             |                             |                                         |                                         |                             |                      |                      |                                   |
| G1CLIIIB                          | 215.7                 | .4                    | 26.3                        | 3.7                         | 133.3                                   | 10.2                                    | .4                          | 9.2                  | 1.3                  | 1.1                               |
| G1CLIII                           | 142.6                 |                       | 31.8                        | 5.3                         | 47.1                                    | .9                                      | 1.5                         | 3.8                  | 3.8                  |                                   |
| JoCLXXII                          | NC                    |                       | 1.3                         | 25.0                        | 1.3                                     |                                         | 6.3                         | 38.8                 | 12.5                 | 47.5                              |
| ToCLX                             | 300.9                 | 2.2                   | .9                          | .4                          | .4                                      |                                         |                             | .9                   |                      |                                   |
| ToCCXLVI                          | 37.6                  |                       |                             |                             |                                         |                                         |                             |                      |                      |                                   |
| SwCXCVI                           | NC                    | 2.3                   | 16.3                        | 2.6                         | 6.7                                     | .4                                      | 2.6                         |                      | 2.6                  | 14.1                              |
| SwCXCVIII                         | NC                    | .4                    | 20.0                        | 1.0                         | .2                                      |                                         | 3.3                         |                      |                      |                                   |
| DiCCXXIII                         | NC                    | 12.6                  | 25.2                        | 3.7                         | 134.7                                   | 15.5                                    | 8.9                         |                      | 24.4                 | 3.3                               |
| MuCXCV                            | NC                    | 1.1                   | .8                          | .1                          | 1.4                                     |                                         | 1.1                         | .1                   | 1.6                  | 7.0                               |
| MuCXCI                            | NC                    | .3                    | 10.6                        | .9                          | 25.0                                    |                                         | .9                          | .1                   | 2.4                  | 2.2                               |
| MuCXCI                            | NC                    | 1.6                   | 4.7                         |                             | 2.1                                     |                                         | 36.8                        | 1.1                  | .5                   | 3.2                               |
| LaCC                              | NC                    | .5                    | .2                          |                             | 2.6                                     | .5                                      |                             |                      |                      |                                   |
| LaCGI                             | NC                    | .3                    | 3.1                         |                             | 89.7                                    | .3                                      |                             | 1.0                  | 1.0                  | 17.2                              |
| HkCCIV                            | NC                    |                       | .3                          |                             | 1.0                                     |                                         | 8.0                         |                      | 13.0                 |                                   |
| HkCCII                            | 44.1                  |                       |                             |                             | .7                                      |                                         | 3.9                         | .2                   |                      | 1.5                               |
| SaCCXVI                           | NC                    | .6                    |                             |                             |                                         |                                         | .6                          | 2.2                  |                      | 36.1                              |
| SaCCXIV                           | 68.2                  |                       |                             |                             |                                         |                                         | .9                          |                      |                      |                                   |
| PoCCX                             | 71.7                  |                       | 63.3                        | 5.0                         | 16.7                                    |                                         | 18.3                        | 3.3                  | 56.7                 |                                   |
| PoCCVII                           | NC                    |                       | 26.4                        | 2.1                         | 25.6                                    | .1                                      | 10.5                        | .1                   | 1.0                  | 9.3                               |
| PoCCVIII                          | NC                    |                       | 39.2                        | 3.4                         | 18.9                                    | .2                                      | 11.7                        | .8                   | 1.6                  | 11.1                              |
| MyCCXXXIV                         | 241.2                 | .1                    | 3.5                         | .1                          | 29.8                                    | .1                                      | .1                          |                      |                      |                                   |
| MyCCXXXV                          | 31.3                  | .2                    | 4.1                         | 1.3                         | 20.6                                    | .1                                      |                             | .4                   | 1.2                  | 4.1                               |
| MyCCXXXVI                         | 194.8                 | .7                    | 18.3                        | .5                          | 36.3                                    | .8                                      | .1                          | 2.2                  | 2.6                  | 1.5                               |
| MyCCXXXVII                        | 43.6                  | .2                    | 12.8                        | 1.8                         | 182.4                                   | .2                                      | 2.6                         | .2                   | 6.0                  | 1.8                               |
| MyCCXXXVIII                       | 169.3                 | .3                    | 28.5                        | 8.5                         | 51.8                                    |                                         | 1.4                         | .8                   | 1.9                  |                                   |
| MyCCXXXIX                         | 623.7                 | 2.0                   | 94.1                        | 12.5                        | 285.4                                   | .3                                      | 8.9                         | 7.3                  | 2.3                  | 6.6                               |
| MyCLIV                            | 393.7                 |                       | 81.2                        | 6.9                         | 26.9                                    |                                         |                             | 1.3                  | 2.5                  |                                   |
| MyCLV                             | 251.8                 | .2                    | 39.1                        | 1.0                         | 84.5                                    | .5                                      |                             | .7                   | .2                   | .5                                |
| MyCLVI                            | 331.2                 | .3                    | 42.1                        | 2.7                         | 12.7                                    | .9                                      | 1.6                         | .9                   | 9.4                  |                                   |
| MyCLVII                           | 716.7                 |                       | 80.6                        | 1.7                         | 20.0                                    |                                         |                             | .6                   | 3.3                  | 9.5                               |
| MyCLVIII                          | 205.5                 |                       | 21.6                        | .8                          | 9.7                                     |                                         |                             | .3                   | .3                   |                                   |
| Av.                               | 137.2                 | 1.6                   | 14.8                        | 3.9                         | 34.6                                    | 2.0                                     | 4.8                         | 4.6                  | 6.5                  | 9.2                               |

|                    | Chironomidae L | Chironomidae P | <u>Promoresia elegans L</u> | <u>Promoresia elegans A</u> | <u>Simulium venustum L</u> | <u>Simulium venustum P</u> | <u>Isoperla bilineata N</u> | Empid sp. 1 L | <u>Hydropsyche L</u> | Hydropsychids (tiny L) |
|--------------------|----------------|----------------|-----------------------------|-----------------------------|----------------------------|----------------------------|-----------------------------|---------------|----------------------|------------------------|
| <u>Scapania</u>    |                |                |                             |                             |                            |                            |                             |               |                      |                        |
| <u>undulata</u>    |                |                |                             |                             |                            |                            |                             |               |                      |                        |
| ToCLXII            | 2520.4         |                | 1.9                         |                             | 142.6                      | 11.1                       |                             | 13.0          | 13.0                 | 31.5                   |
| ToCLIX             | 1023.4         | 2.2            | 2.2                         |                             |                            |                            |                             | 2.2           |                      |                        |
| ToCLXI             | 372.7          | 3.2            | 11.6                        | 4.2                         | 99.1                       |                            | .5                          | 1.9           | .5                   | 4.2                    |
| ToCCXLI            | 153.2          |                |                             | .5                          | 9.5                        | .5                         | .5                          |               | 14.3                 |                        |
| ToCCXLII           | 493.5          |                | 7.4                         | 7.7                         | 2.5                        |                            | 2.5                         | 1.8           | 1.1                  |                        |
| ToCCXLIII          | 376.0          | .8             | 6.2                         | 4.6                         | 4.9                        |                            |                             | 1.3           | 2.1                  | 1.1                    |
| ToCCXLIV           | 317.0          | .3             | .6                          | .6                          | 4.5                        |                            | .3                          |               |                      |                        |
| ToCCXLV            | 337.7          | 2.2            | .2                          |                             | 5.0                        | .5                         | .2                          | 1.0           |                      |                        |
| HkCCV              | NC             | .3             |                             |                             | 5.8                        |                            |                             |               |                      |                        |
| HkCCVI             | 573.0          |                | 10.7                        | .7                          | 5.0                        | .7                         | 10.0                        |               |                      | 9.3                    |
| HkCCIII            | NC             | .4             | .8                          | 1.5                         | 2.7                        |                            | 8.8                         | 2.3           | 2.3                  |                        |
| LaXCIX             | NC             |                | 1.0                         |                             | 14.9                       |                            | .3                          | .5            | 1.3                  | 18.5                   |
| MuXCIV             | 2396.6         | 5.6            | .6                          |                             | 12.9                       |                            | 61.1                        | .6            | 5.6                  | 44.5                   |
| MuXCII             | NC             | 2.1            | 20.7                        |                             |                            |                            |                             | 2.9           |                      |                        |
| MuXC               | NC             | 5.5            | 5.5                         |                             |                            |                            |                             |               |                      |                        |
| Av.                | 1222.9         | 1.4            | 4.3                         | .7                          | 14.3                       | .4                         | 6.9                         | 1.3           | 2.0                  | 10.3                   |
| <u>Hygroambly-</u> |                |                |                             |                             |                            |                            |                             |               |                      |                        |
| <u>stegium</u>     |                |                |                             |                             |                            |                            |                             |               |                      |                        |
| <u>fluviatile</u>  |                |                |                             |                             |                            |                            |                             |               |                      |                        |
| HyCCLIII           | 709.1          | 9.5            | 241.6                       | 10.3                        | 17.0                       | .2                         | 17.6                        | 3.3           | 11.7                 | 6.6                    |
| HyCCXLVII          | 437.6          | 17.6           | 204.5                       | 17.2                        | 11.3                       |                            | 20.6                        | 14.3          | 21.4                 |                        |
| HyCCXLVIII         | 487.4          | 5.2            | 91.7                        | 24.9                        | 10.8                       |                            | .9                          | 2.4           |                      | 3.8                    |
| HyCCXLIX           | 700.5          | .4             | 239.1                       | 19.8                        | 2.6                        |                            | 10.8                        | 3.0           |                      | 1.3                    |
| HyCCLI             | 587.2          | 4.1            | 247.7                       | 49.7                        | 9.0                        |                            | 23.5                        | 4.1           | 15.2                 | 8.3                    |
| ElCLXXXVII         | NC             | .4             | 73.9                        | 3.0                         | 120.9                      |                            | 2.2                         |               | 5.2                  | 19.1                   |
| ElCLXXXVIII        | NC             | 1.8            |                             |                             |                            |                            | 1.0                         |               |                      |                        |
| ElCLXXXVIB         | NC             | 2.1            | 97.0                        | 6.4                         | 16.1                       |                            | 1.4                         |               | 37.5                 | 40.5                   |
| G1CXLVII           | 148.1          |                | 27.4                        | 1.5                         | 5.2                        |                            | 1.5                         | 1.5           | 27.4                 | 1.5                    |
| G1CXLIX            | 67.0           |                | 21.4                        | .5                          | 3.4                        | .1                         | .6                          | .3            | 1.8                  |                        |
| Av.                | 346.0          | 2.9            | 95.4                        | 9.5                         | 20.0                       | .03                        | 5.6                         | 2.1           | 12.8                 | 8.2                    |

|                          | Chironomidae L | Chironomidae P | <u>Promoresia elegans L</u> | <u>Promoresia elegans A</u> | <u>Simulium tuberosum</u><br>complex L | <u>Simulium tuberosum</u><br>complex P | <u>Isoperla bilineata N</u> | Rapid sp. 1 L | <u>Hydropsyche L</u> | Hydropsychids (tiny L) |
|--------------------------|----------------|----------------|-----------------------------|-----------------------------|----------------------------------------|----------------------------------------|-----------------------------|---------------|----------------------|------------------------|
| <u>Eurynchium</u>        |                |                |                             |                             |                                        |                                        |                             |               |                      |                        |
| <u>  riparioides</u>     |                |                |                             |                             |                                        |                                        |                             |               |                      |                        |
| G1CXLVIII                | 107.6          | .5             | 87.7                        | .9                          |                                        |                                        | 1.9                         | .5            |                      |                        |
| G1CL                     | 158.3          | 1.0            | 19.7                        | 2.5                         | 2.0                                    | 1.0                                    | 2.0                         | 2.0           | .5                   | 2.5                    |
| G1CLI                    | 45.4           | .4             | 1.1                         | .4                          |                                        |                                        | .4                          |               |                      |                        |
| G1CLIIA                  | 64.8           |                | 19.1                        |                             | .9                                     |                                        |                             | .3            |                      |                        |
| G1CXLV                   | 125.7          | 2.9            | 41.4                        |                             |                                        |                                        |                             |               | 2.9                  | 1.4                    |
| G1CXLVI                  | 144.4          |                | 16.7                        |                             |                                        |                                        |                             |               |                      | 9.7                    |
| HyCCL                    | 462.1          | 10.5           | 270.8                       | 35.3                        | 1.5                                    |                                        | 14.5                        | 3.0           | 3.8                  | 3.8                    |
| HyCCLII                  | 319.6          | 7.7            | 226.6                       | 10.5                        |                                        |                                        | 16.5                        | 2.8           | .6                   | 2.8                    |
| PoCCIX                   | NC             |                | 36.7                        | 9.0                         |                                        |                                        | 4.7                         | 1.0           | 2.7                  | 5.0                    |
| RKCLXXXVIA               | 207.9          | 1.4            | 20.0                        | 2.9                         |                                        |                                        | 2.9                         | .7            |                      | 42.1                   |
| D1CCXXIV                 | NC             | .3             | 2.1                         | .1                          | .3                                     |                                        | .6                          |               | 13.2                 | 2.9                    |
| D1CCXXIX                 | NC             | 2.2            | 9.6                         | .2                          | 25.2                                   | .4                                     | .6                          | .2            | 13.2                 | 2.0                    |
| D1CCXX                   | NC             | .3             | 27.5                        |                             | 62.1                                   | .3                                     | 6.4                         |               | 33.0                 | 3.8                    |
| D1CCXXI                  | NC             | 1.0            | 2.2                         | .3                          | 67.8                                   | 1.3                                    | 1.3                         | .3            | 10.9                 | 1.0                    |
| D1CCXXII                 | NC             | 3.6            | 3.1                         | .5                          | 34.1                                   | 1.3                                    | .8                          |               | 20.0                 | 34.8                   |
| SaCCXVIII                | NC             | 2.0            | 36.3                        | 8.0                         |                                        |                                        | 4.9                         | .6            | 15.9                 | 150.5                  |
| Av.                      | NC             | 1.8            | 16.1                        | 2.8                         | 12.7                                   | .3                                     | 2.6                         | .7            | 11.4                 | 68.0                   |
| <u>Sciaromium</u>        |                |                |                             |                             |                                        |                                        |                             |               |                      |                        |
| <u>  lescurii</u>        |                |                |                             |                             |                                        |                                        |                             |               |                      |                        |
| LBCCXXIX                 |                |                |                             |                             |                                        |                                        |                             |               |                      | .9                     |
| PoCCXI                   | NC             |                | 110.8                       | 4.6                         | 4.6                                    |                                        | 10.8                        | 1.5           | 6.9                  | 27.7                   |
| P1CXLI                   | 194.6          |                | 1.8                         |                             |                                        |                                        |                             | 5.5           |                      |                        |
| P1CXLI                   | 296.9          | 3.1            |                             |                             |                                        |                                        |                             |               |                      |                        |
| P1CXLI                   | 211.1          | 3.7            |                             |                             |                                        |                                        |                             |               |                      | 7.4                    |
| P1CXLI                   | 103.7          |                |                             |                             |                                        |                                        |                             |               |                      |                        |
| Av.                      | 100.7          | .6             | 37.1                        | 1.5                         | 1.5                                    |                                        | 3.6                         | 1.0           | 2.3                  | 10.2                   |
| <u>Hygrohyponum</u>      |                |                |                             |                             |                                        |                                        |                             |               |                      |                        |
| <u>  luridum</u>         |                |                |                             |                             |                                        |                                        |                             |               |                      |                        |
| MyCCXXII                 | 287.1          | 2.9            | 2.9                         |                             |                                        |                                        | .5                          |               |                      |                        |
| MyCCXXIII                | 222.4          | .6             | 3.5                         | .4                          |                                        |                                        |                             | .2            |                      | .2                     |
| <u>Hygrohyponum</u>      |                |                |                             |                             |                                        |                                        |                             |               |                      |                        |
| <u>  ocraceum</u>        |                |                |                             |                             |                                        |                                        |                             |               |                      |                        |
| SaCCXVII                 | NC             | 8.6            |                             |                             |                                        |                                        |                             |               |                      | 21.4                   |
| <u>Fontinalis</u>        |                |                |                             |                             |                                        |                                        |                             |               |                      |                        |
| <u>  antipyretica</u>    |                |                |                             |                             |                                        |                                        |                             |               |                      |                        |
| <u>    var. gigantea</u> |                |                |                             |                             |                                        |                                        |                             |               |                      |                        |
| SaCCXV                   | NC             | 2.4            |                             |                             |                                        |                                        | .5                          | .5            |                      |                        |
| Undetermined             |                |                |                             |                             |                                        |                                        |                             |               |                      |                        |
| SaCCXIII                 | NC             | 7.7            |                             |                             | .5                                     |                                        | .5                          |               |                      | 7.3                    |
| SwCXCVII                 | NC             | .8             | 57.7                        | 3.1                         | .8                                     |                                        | 22.5                        | 2.3           | 5.4                  | 29.2                   |

|                                         | <u>Leuctra</u> N | <u>Baetis</u> spp. N | <u>Optioservus</u> L | <u>Atherix</u> variegata L | <u>Rhyacophila</u> torva L | <u>Peltoperla</u> N | <u>Dolophiloides</u><br><u>distinctus</u> L | <u>Lepidostoma</u> L | <u>Micrasema</u> (tiny L) | <u>Pericoma</u> L |
|-----------------------------------------|------------------|----------------------|----------------------|----------------------------|----------------------------|---------------------|---------------------------------------------|----------------------|---------------------------|-------------------|
| <u>Fontinalis</u><br><u>dalecarlica</u> |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| G1CLIIIB                                | .2               | 17.6                 |                      |                            | .6                         | 2.6                 |                                             |                      |                           |                   |
| G1CLIII                                 |                  | 15.6                 | .3                   | .3                         | 5.0                        | 2.6                 |                                             |                      |                           | .6                |
| JoCLXXII                                |                  |                      |                      |                            |                            | 2.5                 | 5.0                                         | 1.3                  | 23.8                      |                   |
| ToCLX                                   | 10.6             |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| ToCCXLVI                                | .7               |                      |                      |                            | .3                         |                     | .7                                          |                      |                           | .3                |
| SwCXCVI                                 | 1.1              | 30.7                 |                      |                            |                            | 1.9                 |                                             | 1.9                  | 3.7                       |                   |
| SwCXCVIII                               | .4               | 11.7                 |                      | .2                         |                            | 2.9                 |                                             | 1.9                  | 1.5                       |                   |
| D1CCXXIII                               |                  | 4.8                  |                      | 1.9                        | 1.9                        |                     | .8                                          |                      |                           |                   |
| MuCXCV                                  | 4.0              | 3.3                  | .4                   |                            |                            |                     | .3                                          | .1                   | 1.7                       |                   |
| MuCXCI                                  | 6.3              | 2.6                  | .1                   |                            | 10.1                       | .3                  | 19.3                                        |                      | .4                        |                   |
| MuCXCI                                  |                  | 9.5                  | .5                   |                            |                            |                     |                                             |                      | 7.9                       |                   |
| LaCC                                    | .5               | 3.5                  |                      |                            | .5                         |                     |                                             |                      |                           |                   |
| LaCCI                                   | 8.6              | 1.7                  | 1.7                  |                            | 2.8                        | 2.8                 |                                             |                      |                           |                   |
| HkCCIV                                  | 1.0              | 8.7                  |                      | 1.3                        | .3                         | 2.3                 | .3                                          | .3                   |                           |                   |
| HkCCII                                  | .8               | 7.3                  |                      | .3                         | 1.7                        |                     |                                             | .2                   |                           |                   |
| SwCCXVI                                 |                  |                      |                      | .6                         |                            |                     |                                             | 8.9                  |                           |                   |
| SwCCXIV                                 |                  |                      |                      |                            |                            |                     |                                             | 31.8                 |                           |                   |
| PoCCX                                   |                  | 11.7                 |                      |                            |                            | 3.3                 |                                             |                      | 38.3                      |                   |
| PoCCVII                                 |                  | 14.4                 | .2                   |                            |                            | 7.5                 |                                             | .4                   | 11.1                      |                   |
| PoCCVIII                                | .1               | 18.7                 | .1                   | .1                         |                            | 8.0                 |                                             | .1                   | 18.0                      |                   |
| MyCCXXXIV                               |                  | 9.3                  | .8                   |                            | 6.4                        |                     | .1                                          |                      |                           |                   |
| MyCCXXXV                                | .5               | 1.7                  |                      | .1                         | .1                         |                     | 5.3                                         |                      |                           |                   |
| MyCCXXXVI                               | .1               | 6.8                  | 1.3                  | .1                         | .3                         |                     |                                             |                      | .1                        |                   |
| MyCCXXXVII                              |                  | 4.2                  |                      | .3                         | 1.5                        |                     | 1.2                                         |                      |                           |                   |
| MyCCXXXVIII                             | 1.4              | 3.8                  | 1.3                  |                            |                            |                     |                                             | .4                   | .2                        | .1                |
| MyCCXXXIX                               | .7               | 20.5                 | .3                   |                            |                            |                     |                                             |                      | 1.7                       |                   |
| MyCLIV                                  |                  | 22.5                 | 4.4                  |                            |                            |                     |                                             |                      |                           |                   |
| MyCLV                                   | .2               | 6.2                  |                      |                            |                            |                     |                                             |                      |                           |                   |
| MyCLVI                                  | .3               | 14.5                 | 2.4                  |                            |                            |                     |                                             |                      |                           |                   |
| MyCLVII                                 |                  | 18.9                 | .6                   |                            |                            |                     |                                             |                      |                           |                   |
| MyCLVIII                                | 4.6              | 11.3                 | .2                   |                            |                            |                     |                                             |                      |                           |                   |
| Av.                                     | 1.3              | 10.9                 | .3                   | .3                         | 1.1                        | 1.5                 | .7                                          | 2.3                  | 4.8                       | .05               |



|                    | <u>Leuctra</u> N | <u>Baetis</u> spp. N | <u>Optioservus</u> L | <u>Atherix variegata</u> L | <u>Rhyacophila torva</u> L | <u>Peltoberla</u> N | <u>Dolophiloides</u><br><u>distinctus</u> L | <u>Lepidostoma</u> L | <u>Micrasema</u> (tiny L) | <u>Pericoma</u> L |
|--------------------|------------------|----------------------|----------------------|----------------------------|----------------------------|---------------------|---------------------------------------------|----------------------|---------------------------|-------------------|
| <u>Scapania</u>    |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| <u>undulata</u>    |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| ToCLXII            | 133.4            |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| ToCLIX             | 35.6             |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| ToCLXI             | 70.4             |                      |                      |                            | 1.0                        | 3.7                 |                                             |                      |                           |                   |
| ToCCXLI            | 3.2              |                      | .5                   |                            | 5.4                        | 3.2                 | .5                                          |                      |                           |                   |
| ToCCXLII           | 50.8             |                      | .4                   |                            | 9.2                        | 1.1                 | 3.2                                         |                      |                           |                   |
| ToCCXLIII          | 35.4             | .8                   |                      |                            | 18.1                       | 1.9                 | 4.3                                         |                      |                           |                   |
| ToCCXLIV           | 35.0             | .3                   |                      |                            | 12.9                       | .8                  | 4.2                                         |                      |                           |                   |
| ToCCXLV            | 42.2             |                      | .7                   | .5                         | 7.6                        | 2.8                 | 1.4                                         |                      |                           |                   |
| HkCCV              | .8               | 10.8                 |                      | 1.5                        | 12.8                       |                     |                                             |                      |                           | .5                |
| HkCCVI             | 5.0              | 3.6                  |                      | 1.4                        |                            |                     | 2.9                                         |                      |                           | .7                |
| HkCCIII            | .4               | 11.9                 |                      | 3.8                        | 1.2                        |                     |                                             | 2.0                  |                           |                   |
| LaCXCIX            | 1.8              | 1.0                  |                      |                            | 2.1                        | 1.0                 |                                             | .3                   |                           |                   |
| MuCXCI             | 4.5              | 20.0                 | 3.9                  |                            | .6                         |                     | 1.2                                         |                      | 17.8                      |                   |
| MuCXCI             | 1.4              | .7                   |                      |                            |                            |                     |                                             | 3.6                  | 89.3                      |                   |
| MuCX               | 4.5              |                      |                      |                            |                            |                     |                                             |                      | .9                        |                   |
| Av.                | 14.5             | 4.2                  | .4                   | .6                         | 3.5                        | .7                  | .8                                          | .6                   | 9.0                       | .1                |
| <u>Hygroambly-</u> |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| <u>stegium</u>     |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| <u>fluviatile</u>  |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| HyCCLIII           | .9               | 31.5                 | .2                   | 2.6                        | 2.6                        | 33.0                |                                             | .9                   | 29.0                      | .7                |
| HyCCXLVII          | .8               | 31.8                 | 1.7                  | 2.1                        | 3.8                        | 67.2                | .8                                          | .8                   | 22.3                      | .8                |
| HyCCXLVIII         | .5               | 12.2                 |                      | 5.2                        | 4.7                        | 17.9                | .5                                          |                      | 4.3                       |                   |
| HyCCXLIX           |                  | 26.2                 | .4                   | 1.3                        | 1.7                        | 5.6                 |                                             | 1.3                  | 56.4                      | .4                |
| HyCCLI             |                  | 41.4                 |                      | 1.4                        | 4.2                        | 29.7                | 1.4                                         | 2.1                  | 53.1                      | .7                |
| ElCLXXXVII         |                  | 3.5                  |                      |                            | 2.2                        |                     | 9.1                                         | .4                   | 1.3                       | .9                |
| ElCLXXXVIII        | .5               | 11.8                 |                      | .5                         |                            | .5                  | 9.5                                         |                      |                           |                   |
| ElCLXXXVIB         |                  | 1.3                  | .1                   |                            |                            |                     | .8                                          | .2                   |                           | 1.3               |
| GicXLVII           |                  | 14.8                 | 4.4                  | 8.1                        |                            | 14.1                | .7                                          | .7                   | 5.9                       |                   |
| GicXLIX            | .1               | 2.7                  | .4                   | 1.6                        | .1                         | 2.5                 | .1                                          |                      | 1.1                       | 2.2               |
| Av.                | .3               | 14.3                 | 1.0                  | 2.5                        | 1.4                        | 13.0                | 2.5                                         | .5                   | 12.3                      | .8                |



|                        | <u>Leuctra</u> N | <u>Baetis</u> spp. N | <u>Optioservus</u> L | <u>Atherix variegata</u> L | <u>Rhyacophila torva</u> L | <u>Peltoberla</u> N | <u>Dolophiloides</u><br><u>distinctus</u> L | <u>Lepidostoma</u> L | <u>Microsema</u> (tiny L) | <u>Pericoma</u> L |
|------------------------|------------------|----------------------|----------------------|----------------------------|----------------------------|---------------------|---------------------------------------------|----------------------|---------------------------|-------------------|
| <u>Eurynchium</u>      |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| <u>  ribarioides</u>   |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| G1CXLVIII              | .5               | 2.8                  | 2.4                  | 1.4                        |                            | .9                  |                                             | .5                   | .9                        | 4.7               |
| G1CL                   | 2.9              | 6.9                  | 3.4                  | 4.4                        |                            | 4.9                 |                                             |                      | 5.9                       | 2.5               |
| G1CLI                  | 1.4              |                      | .4                   | .4                         |                            |                     |                                             |                      | 2.1                       | .4                |
| G1CLIIA                |                  | .4                   | .4                   | 1.7                        |                            |                     |                                             |                      |                           |                   |
| G1CXIV                 | 1.4              |                      | 5.7                  | 1.4                        |                            |                     |                                             | 1.4P                 |                           | 20.0              |
| G1CXLVI                |                  |                      | 4.2                  | 1.4                        |                            |                     |                                             | 1.4P                 |                           | 47.2              |
| HyCCL                  | 1.5              | 15.8                 | 1.5                  | 4.5                        | 1.5                        | 27.8                |                                             |                      | 39.0                      | .8                |
| HyCCLII                | 2.2              | 12.1                 | .6                   | 2.2                        | 1.7                        | 13.2                |                                             |                      | 34.1                      |                   |
| PoCCIX                 | .7               | 2.0                  |                      | 6.0                        |                            | 1.0                 | 3.0                                         |                      | 11.0                      |                   |
| RKCLXXXVIA             |                  | 5.0                  |                      |                            |                            | 1.4                 |                                             |                      | .7                        | 1.4               |
| D1CCXXIV               |                  | .6                   |                      | .3                         | 3.2                        |                     |                                             |                      |                           |                   |
| D1CCXXIX               |                  | 5.6                  | .2                   | 2.6                        | 3.0                        |                     | .2                                          | .2                   |                           |                   |
| D1CCXX                 |                  | 2.6                  |                      |                            | 1.9                        |                     |                                             |                      |                           |                   |
| D1CCXXI                |                  | 4.2                  |                      |                            | 1.6                        |                     | .6                                          |                      |                           |                   |
| D1CCXXII               |                  | 2.6                  |                      | .5                         |                            |                     |                                             |                      |                           | .3                |
| SaCCXVIII              |                  | 11.4                 |                      | .6                         | .2                         |                     | .2                                          | 16.2                 | 9.2                       |                   |
| Av.                    | .6               | 6.2                  | .5                   | 2.1                        | .6                         | 4.0                 | .6                                          | 3.2                  | 9.8                       | 2.3               |
| <u>Sciaromium</u>      |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| <u>  lescurii</u>      |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| LBCCXXIX               |                  |                      | 6.5                  | .9                         |                            |                     |                                             | 2.8                  |                           | .9P               |
| PoCCXI                 |                  | 5.4                  |                      | 1.5                        |                            | 1.5                 |                                             |                      | 25.4                      |                   |
| P1CXLI                 |                  |                      |                      |                            |                            |                     |                                             |                      |                           | 63.6              |
| P1CXLI                 |                  | 34.4                 |                      |                            |                            |                     |                                             | .3                   |                           | 175.0             |
| P1CXLI                 |                  |                      |                      | 3.7                        |                            |                     |                                             | 3.7                  |                           | 96.3              |
| P1CXLI                 |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| Av.                    |                  | 4.7                  | 2.2                  | 1.1                        |                            | .5                  |                                             | 1.8                  | 8.5                       | 28.2              |
| <u>Hygrohypnum</u>     |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| <u>  luridum</u>       |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| MyCCXXXII              |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| MyCCXXXIII             |                  | .2                   | .8                   |                            | .8                         |                     |                                             |                      |                           | .2                |
| <u>Hygrohypnum</u>     |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| <u>  ocraceum</u>      |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| SaCCXVII               | 1.4              |                      |                      | .7                         |                            |                     |                                             | 16.4                 |                           |                   |
| <u>Fontinalis</u>      |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| <u>  antipyretica</u>  |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| <u>  var. gigantea</u> |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| SaCCXV                 |                  |                      |                      |                            |                            |                     |                                             | 7.6                  |                           |                   |
| Undetermined           |                  |                      |                      |                            |                            |                     |                                             |                      |                           |                   |
| SaCCXIII               |                  |                      |                      |                            |                            | .5                  |                                             | 23.2                 |                           |                   |
| SwCXCVII               | 4.6              | 12.3                 |                      | .8                         |                            | 2.3                 | 2.3                                         | 6.2                  |                           | 7.6               |



|                               | <u>Bezzia group 2 L</u> | <u>Bezzia sp. 1</u> | <u>Paraleptophlebia spp. N</u> | <u>Diplectrona modesta L</u> | <u>Ephemerella invaria group N</u> | <u>Empid sp. 2</u> | <u>Hydroptila L</u> | <u>Hydroptila P</u> | <u>Ephemerella serratoides N</u> | <u>Optioservus sp. 2 A</u> |
|-------------------------------|-------------------------|---------------------|--------------------------------|------------------------------|------------------------------------|--------------------|---------------------|---------------------|----------------------------------|----------------------------|
| <u>Fontinalis dalecarlica</u> |                         |                     |                                |                              |                                    |                    |                     |                     |                                  |                            |
| GiCLIIIB                      | 1.5                     |                     | .2                             |                              |                                    |                    |                     |                     |                                  |                            |
| GiCLIIII                      |                         | .6                  |                                |                              |                                    |                    |                     |                     |                                  |                            |
| JoCLXXII                      | 1.3                     |                     |                                |                              | 2.5                                |                    | 1.3                 | 11.3                |                                  |                            |
| ToCLX                         |                         |                     |                                |                              |                                    |                    |                     |                     |                                  |                            |
| ToCCXLVI                      |                         |                     |                                |                              |                                    | .3                 |                     |                     |                                  |                            |
| SwCXCVI                       |                         | .4                  | .4                             | .4                           | 1.1                                | .4                 |                     |                     |                                  |                            |
| SwCXCVIII                     |                         |                     | .8                             |                              | .2                                 |                    |                     | .2                  |                                  |                            |
| DiCCXXIII                     |                         |                     |                                |                              | 4.4?                               | 1.1                |                     |                     | 7.4                              |                            |
| MuCXCV                        |                         |                     |                                |                              | .7?                                | .2                 |                     | .1                  |                                  | .1                         |
| MuCXCI                        |                         |                     |                                |                              |                                    | .3                 |                     |                     |                                  | .3                         |
| MuCXCI                        |                         |                     |                                |                              | .5?                                |                    |                     |                     | .5                               | 1.6                        |
| LaCC                          | .2                      |                     |                                | .5                           |                                    |                    |                     |                     |                                  |                            |
| LaCCI                         |                         | .3                  |                                | 3.1                          |                                    |                    | 1.8                 |                     |                                  |                            |
| HkCCIV                        |                         |                     |                                | 4.7                          | 3.0                                |                    |                     |                     |                                  |                            |
| HkCCII                        | .2                      |                     |                                |                              |                                    |                    |                     |                     |                                  |                            |
| SaCCXVI                       |                         |                     |                                |                              |                                    |                    |                     |                     |                                  |                            |
| SaCCXIV                       |                         |                     | 4.5                            |                              |                                    |                    |                     |                     |                                  |                            |
| PoCCX                         |                         |                     |                                |                              |                                    |                    |                     |                     |                                  |                            |
| PoCCVII                       |                         |                     | .2                             | .1                           | .4                                 |                    |                     |                     |                                  |                            |
| PoCCVIII                      |                         |                     |                                |                              |                                    |                    |                     |                     | .1                               |                            |
| MyCCXXIV                      |                         |                     |                                |                              |                                    | .1                 | .4                  |                     |                                  | .5                         |
| MyCCXXV                       |                         |                     | .2                             | 5.5                          |                                    | .5                 |                     |                     |                                  |                            |
| MyCCXXVI                      |                         |                     |                                | .3                           |                                    | .2                 |                     |                     |                                  |                            |
| MyCCXXVII                     |                         |                     |                                | .2                           |                                    | 1.6                |                     |                     |                                  |                            |
| MyCCXXVIII                    |                         |                     |                                | 3.4                          |                                    | 1.0                |                     |                     |                                  |                            |
| MyCCXXIX                      |                         |                     |                                | 1.7                          |                                    | .7                 |                     |                     |                                  |                            |
| MyCLIV                        |                         |                     |                                |                              |                                    |                    |                     |                     | .6                               |                            |
| MyCLV                         |                         |                     |                                | .2P                          |                                    |                    |                     |                     |                                  |                            |
| MyCLVI                        |                         |                     |                                | 10.6                         |                                    |                    |                     | .3                  |                                  |                            |
| MyCLVII                       |                         |                     |                                |                              |                                    |                    |                     |                     | .6                               |                            |
| MyCLVIII                      |                         |                     |                                |                              |                                    |                    |                     |                     | .3                               |                            |
| Av.                           | .2                      | .1                  | .3                             | .6                           | .9                                 | .2                 | .2                  | 1.0                 | .7                               | .1                         |

|                    | <u>Bezzia group 2 L</u> | <u>Bezzia sp. 1</u> | <u>Paraleptophlebia spp. N</u> | <u>Diplectrona modesta L</u> | <u>Ephemerella invaria group N</u> | <u>Empid sp. 2</u> | <u>Hydroptila L</u> | <u>Hydroptila P</u> | <u>Ephemerella serratoidea N</u> | <u>Optioservus sp. 2 A</u> |
|--------------------|-------------------------|---------------------|--------------------------------|------------------------------|------------------------------------|--------------------|---------------------|---------------------|----------------------------------|----------------------------|
| <u>Scapania</u>    |                         |                     |                                |                              |                                    |                    |                     |                     |                                  |                            |
| <u>undulata</u>    |                         |                     |                                |                              |                                    |                    |                     |                     |                                  |                            |
| ToCLXII            |                         |                     |                                |                              |                                    |                    |                     |                     |                                  |                            |
| ToCLIX             | 3.3                     |                     |                                |                              |                                    |                    |                     |                     |                                  |                            |
| ToCLXI             |                         | .5                  |                                |                              |                                    |                    |                     |                     |                                  | .5                         |
| ToCCXLI            |                         |                     |                                | 2.1                          | .5                                 | .5                 |                     |                     |                                  | .5                         |
| ToCCXLII           | 1.1P                    |                     |                                |                              | .7                                 | .7                 |                     |                     |                                  | 1.8                        |
| ToCCXLIII          |                         |                     | .5                             |                              |                                    |                    |                     |                     |                                  | 1.9                        |
| ToCCXLIV           |                         |                     |                                | .3                           |                                    | .8                 |                     |                     |                                  | .3                         |
| ToCCXLV            | .2P                     |                     |                                |                              |                                    | .5                 |                     |                     |                                  |                            |
| HkCCV              | .3                      |                     |                                |                              |                                    | .5                 |                     |                     | 1.8                              |                            |
| HkCCVI             | .7                      |                     |                                |                              | 4.3                                |                    |                     |                     |                                  |                            |
| HkCCIII            |                         | .4                  |                                | 7.3                          | 8.5                                |                    |                     |                     |                                  |                            |
| LaCXCIX            |                         |                     |                                |                              |                                    |                    | .3                  |                     |                                  |                            |
| MuXCIV             |                         |                     |                                | 1.7                          | 3.3                                |                    |                     | 1.1                 |                                  | 1.1                        |
| MuXCII             |                         |                     | 2.9                            |                              |                                    |                    | 2.8                 | 7.1                 |                                  |                            |
| MuXC               |                         |                     | 4.5                            |                              |                                    |                    | 2.7                 |                     |                                  |                            |
| Av.                | .2                      | .04                 | .6                             | .3                           | 1.4                                | .1                 | .5                  | .7                  | .15                              | 2.5                        |
| <u>Hygroambly-</u> |                         |                     |                                |                              |                                    |                    |                     |                     |                                  |                            |
| <u>stegium</u>     |                         |                     |                                |                              |                                    |                    |                     |                     |                                  |                            |
| <u>fluviatile</u>  |                         |                     |                                |                              |                                    |                    |                     |                     |                                  |                            |
| HyCCLIII           |                         | 5.3                 | 1.7                            | .4                           | 8.3                                |                    |                     |                     |                                  |                            |
| HyCCXLVII          | 5.0                     | .8                  | 1.7                            | 43.3                         | 12.6                               |                    |                     |                     |                                  |                            |
| HyCCXLVIII         | 2.9                     | .9                  |                                |                              | 1.9                                |                    |                     |                     |                                  |                            |
| HyCCXLIX           | 1.7                     | 9.0                 |                                |                              | 18.9                               |                    |                     |                     |                                  |                            |
| HyCCLI             |                         | 4.1                 | .7                             |                              | 15.2                               |                    |                     |                     |                                  |                            |
| ElCLXXXVII         |                         | 1.7                 | 2.2                            | 2.6                          | 3.0                                |                    |                     |                     | 5.2                              |                            |
| ElCLXXXVIII        |                         |                     | 1.8                            |                              |                                    |                    |                     |                     |                                  |                            |
| ElCLXXXVIB         |                         | .4                  | .5                             |                              | 1.0                                |                    | .7                  | .1                  | 4.4                              |                            |
| GlCXLVII           | .7                      | .7                  |                                | 1.4                          |                                    |                    |                     |                     |                                  |                            |
| GlCXLIX            | .1                      | .3                  |                                |                              |                                    |                    |                     |                     |                                  |                            |
| Av.                | .8                      | 1.6                 | .8                             | 3.4                          | 4.2                                |                    | .1                  | .01                 | 1.1                              |                            |

|                        | <u>Bezzia group 2 L</u> | <u>Bezzia sp. 1</u> | <u>Paraleptophlebia spp. N</u> | <u>Diplectrona modesta L</u> | <u>Ephemerella invaria</u><br><u>group N</u> | <u>Emold sp. 2</u> | <u>Hydroptila L</u> | <u>Hydroptila P</u> | <u>Ephemerella serratoidea</u><br><u>N</u> | <u>Optioservus sp. 2 A</u> |
|------------------------|-------------------------|---------------------|--------------------------------|------------------------------|----------------------------------------------|--------------------|---------------------|---------------------|--------------------------------------------|----------------------------|
| <u>Eurynechium</u>     |                         |                     |                                |                              |                                              |                    |                     |                     |                                            |                            |
| <u>  riparioides</u>   |                         |                     |                                |                              |                                              |                    |                     |                     |                                            |                            |
| G1CXLVIII              | .9                      | 1.4                 | 6.6                            | .5                           |                                              |                    |                     |                     |                                            |                            |
| G1CL                   | 2.9                     | .5                  | 15.2                           |                              |                                              |                    |                     |                     |                                            | .5                         |
| G1CLI                  |                         | 1.1                 | 2.5                            | .4                           |                                              |                    |                     | .7                  |                                            |                            |
| G1CLIIA                | 2.2                     | .4                  |                                |                              |                                              |                    |                     |                     |                                            |                            |
| G1CXLV                 | 1.4                     | 2.9                 | 2.9                            |                              |                                              |                    |                     | 1.4                 |                                            |                            |
| G1CXLVI                | 11.1                    |                     | 8.3                            |                              |                                              |                    |                     |                     |                                            |                            |
| HyCCL                  | 2.3                     | 1.5                 | 9.8                            |                              | 17.3                                         |                    |                     |                     |                                            | .8                         |
| HyCCLII                | .6P                     | 2.2                 | 6.6                            |                              | 14.3                                         |                    |                     |                     |                                            |                            |
| PoCCIX                 | .7                      |                     | 1.3                            |                              |                                              |                    |                     |                     |                                            |                            |
| hKCLXXXVIA             |                         |                     |                                |                              |                                              | .7                 | .3                  |                     | 7.1                                        |                            |
| D1CCXXIV               |                         |                     |                                |                              |                                              |                    |                     |                     |                                            |                            |
| D1CCXXIX               |                         |                     |                                |                              | 1.4                                          |                    |                     |                     | .4                                         |                            |
| D1CCXX                 |                         |                     |                                |                              | 4.8                                          |                    |                     |                     | .3                                         | .6                         |
| D1CCXXI                |                         |                     |                                |                              | 2.9                                          |                    |                     |                     | .6                                         |                            |
| D1CCXXII               |                         |                     | .3                             |                              |                                              |                    |                     |                     | 1.0                                        |                            |
| SaCCXVIII              |                         |                     | 10.2                           | 23.1                         | 5.1                                          |                    |                     |                     | 1.8                                        |                            |
| Av.                    | 1.2                     | .3                  | 4.3                            | 3.9                          | 3.8                                          | .1                 | .05                 | .1                  | 1.6                                        | .1                         |
| <u>Sciaromium</u>      |                         |                     |                                |                              |                                              |                    |                     |                     |                                            |                            |
| <u>  lescurii</u>      |                         |                     |                                |                              |                                              |                    |                     |                     |                                            |                            |
| LBCCXXIX               | .9                      | .9                  | 1.9                            |                              |                                              |                    |                     |                     |                                            |                            |
| PoCCXI                 |                         |                     | 1.5                            |                              |                                              |                    |                     |                     |                                            |                            |
| P1CXLI                 | 1.8                     |                     | 5.5                            |                              |                                              |                    |                     |                     |                                            |                            |
| P1CXLI                 |                         | 3.1                 |                                |                              |                                              |                    |                     |                     |                                            |                            |
| P1CXLI                 | 11.1                    |                     |                                |                              |                                              |                    |                     |                     |                                            |                            |
| P1CXLI                 | 1.2P                    |                     |                                |                              |                                              |                    |                     |                     |                                            |                            |
| Av.                    | 1.5                     | .6                  | 1.6                            |                              |                                              |                    |                     |                     |                                            |                            |
| <u>Hygrohypnum</u>     |                         |                     |                                |                              |                                              |                    |                     |                     |                                            |                            |
| <u>  luridum</u>       |                         |                     |                                |                              |                                              |                    |                     |                     |                                            |                            |
| MyCCXXXII              |                         |                     |                                |                              |                                              |                    | .5                  |                     |                                            | 1.9                        |
| MyCCXXXIII             |                         |                     |                                |                              |                                              |                    | .5                  |                     |                                            | 1.0                        |
| <u>Hygrohypnum</u>     |                         |                     |                                |                              |                                              |                    |                     |                     |                                            |                            |
| <u>  ocraceum</u>      |                         |                     |                                |                              |                                              |                    |                     |                     |                                            |                            |
| SaCCXVII               |                         |                     | 2.1                            |                              |                                              |                    |                     |                     |                                            |                            |
| <u>Fontinalis</u>      |                         |                     |                                |                              |                                              |                    |                     |                     |                                            |                            |
| <u>  antipyretica</u>  |                         |                     |                                |                              |                                              |                    |                     |                     |                                            |                            |
| <u>  var. gigantea</u> |                         |                     |                                |                              |                                              |                    |                     |                     |                                            |                            |
| SaCCXV                 |                         |                     | 2.4                            |                              |                                              |                    |                     |                     |                                            |                            |
| Undetermined           |                         |                     |                                |                              |                                              |                    |                     |                     |                                            |                            |
| SaCCXIII               |                         |                     | 8.2                            |                              | .5                                           |                    |                     |                     |                                            |                            |
| SwCXCVII               |                         |                     | 7.6                            | 2.3                          | .8                                           | .8                 |                     | 2.3                 |                                            |                            |

|                                         | <u>Micrasema</u> sp. 2 L | <u>Stenelmis</u> crenata A | <u>Cheumatopsyche</u> L | <u>Brachycentrid</u> gen. 1<br>L | <u>Limnophora</u> L | <u>Limnophora</u> P | <u>Rhyacophila</u> carolina L | <u>Rhyacophila</u> fuscula L | <u>Ephemerella</u> attenuata N | <u>Pteronarcys</u> biloba N |
|-----------------------------------------|--------------------------|----------------------------|-------------------------|----------------------------------|---------------------|---------------------|-------------------------------|------------------------------|--------------------------------|-----------------------------|
| <u>Fontinalis</u><br><u>dalecarlica</u> |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| G1CLIIIB                                |                          | .2                         |                         |                                  |                     |                     |                               | .4                           |                                |                             |
| G1CLIII                                 |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| JoCLXXII                                | 2.5P                     |                            | 17.5                    |                                  |                     |                     |                               |                              |                                |                             |
| ToCLX                                   |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| ToCCXLVI                                |                          |                            |                         |                                  |                     |                     | 18.5                          |                              |                                |                             |
| SwCXCVI                                 |                          |                            |                         | 1.1                              |                     |                     |                               |                              | 1.1                            |                             |
| SwCXCVIII                               |                          |                            |                         | .6                               |                     |                     |                               |                              | 1.0                            |                             |
| D1CCXXIII                               | 4.8                      |                            |                         |                                  |                     |                     |                               |                              |                                | .4                          |
| MuCXCV                                  |                          |                            |                         |                                  |                     |                     |                               | .3                           | .6                             |                             |
| MuCXCI                                  |                          |                            |                         |                                  |                     |                     |                               | .5                           |                                |                             |
| LaCC                                    |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| LaCCI                                   |                          |                            |                         |                                  |                     |                     |                               | .7                           |                                |                             |
| HkCCIV                                  |                          |                            |                         |                                  |                     |                     | 4.0                           |                              |                                |                             |
| HkCCII                                  |                          |                            |                         |                                  |                     |                     | .2                            |                              |                                |                             |
| SaCCXVI                                 |                          |                            |                         | 19.4                             | 1.1                 |                     |                               |                              |                                |                             |
| SaCCXIV                                 |                          |                            |                         | 11.8                             |                     |                     |                               |                              |                                |                             |
| PoCCX                                   |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| PoCCVII                                 |                          |                            |                         |                                  |                     |                     |                               |                              |                                | .4                          |
| PoCCVIII                                |                          |                            |                         |                                  |                     |                     |                               | .1                           |                                | .3                          |
| MyCCXXXIV                               |                          |                            |                         |                                  | .4                  |                     | .1                            |                              |                                |                             |
| MyCCXXXV                                |                          | .2                         | .1                      |                                  | .1                  |                     | .1                            | .1                           |                                | .1                          |
| MyCCXXXVI                               |                          | .1                         | 2.2                     |                                  |                     |                     |                               |                              |                                |                             |
| MyCCXXXVII                              |                          | .9                         | .6                      |                                  |                     |                     | .2                            |                              |                                |                             |
| MyCCXXXVIII                             |                          | .9                         | .7                      |                                  |                     |                     |                               |                              |                                | .4                          |
| MyCCXXXIX                               |                          | 1.0                        | 1.0                     |                                  |                     |                     |                               |                              |                                | .3                          |
| MyCLIV                                  | 1.9                      | 3.8                        | 3.2                     |                                  |                     |                     |                               |                              | 1.3                            |                             |
| MyCLV                                   | 1.0                      | .2                         |                         |                                  |                     |                     |                               |                              | .2                             |                             |
| MyCLVI                                  | .9                       | .6                         |                         |                                  |                     |                     |                               |                              | .6                             |                             |
| MyCLVII                                 | 2.2                      |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| MyCLVIII                                |                          | .8                         |                         |                                  |                     |                     |                               |                              | .2                             | .2                          |
| Av.                                     | .7                       | .1                         | 1.7                     | 1.5                              | .1                  |                     | 1.0                           | .1                           | .1                             | .1                          |

|                    | <u>Microsema</u> sp. 2 L | <u>Stenelmis</u> crenata A | <u>Cheumatopsyche</u> L | <u>Brachycentrid</u> gen. 1<br>L | <u>Limnophora</u> L | <u>Limnophora</u> P | <u>Rhyacophila</u> carolina L | <u>Rhyacophila</u> fuscata L | <u>Ephemerella</u> attenuata N | <u>Pteronarcys</u> biloba N |
|--------------------|--------------------------|----------------------------|-------------------------|----------------------------------|---------------------|---------------------|-------------------------------|------------------------------|--------------------------------|-----------------------------|
| <u>Scapania</u>    |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| <u>undulata</u>    |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| ToCLXII            |                          |                            |                         |                                  |                     |                     | 3.7                           |                              |                                |                             |
| ToCLIX             |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| ToCLXI             |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| ToCCXLI            |                          |                            |                         |                                  |                     |                     | .5                            |                              |                                |                             |
| ToCCXLII           |                          |                            |                         |                                  |                     |                     | 5.3                           |                              |                                |                             |
| ToCCXLIII          |                          |                            |                         |                                  |                     |                     | .5                            |                              |                                |                             |
| ToCCXLIV           |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| ToCCXLV            |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| HkCCV              |                          |                            |                         | .3                               | .3                  |                     |                               |                              |                                |                             |
| HkCCVI             |                          |                            |                         | 1.4                              |                     |                     |                               |                              |                                |                             |
| HkCCIII            |                          |                            |                         | .4                               | .4                  |                     |                               |                              |                                |                             |
| LaCXCI             |                          |                            |                         |                                  |                     |                     |                               | .3                           |                                |                             |
| MuCXCI             |                          |                            |                         |                                  |                     |                     |                               | 1.7                          | 1.7                            |                             |
| MuCXCI             |                          |                            |                         |                                  |                     |                     |                               |                              | 7.1                            |                             |
| MuCX               |                          |                            |                         |                                  |                     |                     |                               |                              | 9.1                            |                             |
| Av.                |                          |                            |                         | .2                               | .05                 |                     | 1.3                           | .2                           | 1.5                            |                             |
| <u>Hygroambly-</u> |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| <u>stegium</u>     |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| <u>fluviatile</u>  |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| HyCCLIII           | 1.1                      |                            | 1.1                     | .2                               |                     |                     |                               |                              |                                |                             |
| HyCCXLVII          |                          |                            |                         | .4                               |                     |                     |                               | .8                           |                                |                             |
| HyCCXLVIII         |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| HyCCXLIX           |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| HyCCLI             | 4.8                      |                            |                         | .7                               |                     |                     |                               |                              |                                |                             |
| ElCLXXXVII         |                          |                            |                         | 11.4                             |                     |                     |                               | .4                           |                                |                             |
| ElCLXXXVIII        |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| ElCLXXXVIB         | .6                       |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| GicXLVII           |                          |                            | 1.5                     |                                  |                     |                     |                               |                              |                                |                             |
| GicXLIX            |                          | .1                         |                         |                                  |                     |                     |                               |                              |                                |                             |
| Av.                | .5                       | .02                        | .3                      | 1.4                              |                     |                     |                               | .1                           |                                |                             |

|                      | <u>Microsema</u> sp. 2 L | <u>Stenelmis</u> crenata A | <u>Cheumatopsyche</u> L | <u>Brachycentrid</u> gen. 1<br>L | <u>Limnophora</u> L | <u>Limnophora</u> P | <u>Rhyacophila</u> carolina L | <u>Rhyacophila</u> fuscata L | <u>Sphemerella</u> attenuata N | <u>Pteronarcys</u> biloba N |
|----------------------|--------------------------|----------------------------|-------------------------|----------------------------------|---------------------|---------------------|-------------------------------|------------------------------|--------------------------------|-----------------------------|
| <u>Eurynchium</u>    |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| <u>riparioides</u>   |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| G1CXLVIII            |                          | 1.4                        |                         |                                  |                     |                     |                               |                              |                                |                             |
| G1CL                 |                          | .5                         |                         |                                  |                     |                     |                               |                              |                                |                             |
| G1CL                 |                          | .4L                        |                         |                                  |                     |                     |                               |                              |                                |                             |
| G1CLIIA              |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| G1CLV                |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| G1CXLVI              |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| HyCCL                |                          |                            |                         | .8                               | .8                  |                     |                               |                              |                                |                             |
| HyCCLII              | .6                       |                            |                         |                                  |                     |                     |                               | .6                           |                                |                             |
| PoCCIX               |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| RKCLXXXVIA           |                          |                            | 18.6                    |                                  |                     |                     |                               |                              |                                |                             |
| D1CCXXIV             | .4                       |                            |                         |                                  | .1                  |                     |                               |                              |                                |                             |
| D1CCXIX              | .4                       |                            |                         |                                  | .2                  |                     | .2                            |                              |                                |                             |
| D1CCXX               | 3.2                      |                            |                         |                                  | 11.2                | 1.0                 |                               |                              |                                |                             |
| D1CCXXI              | .6                       |                            |                         |                                  | 6.1                 | 1.0                 |                               |                              |                                |                             |
| D1CCXXII             | 6.0                      |                            |                         |                                  |                     |                     |                               |                              |                                | .3                          |
| SaCCXVIII            | .4                       |                            |                         |                                  |                     |                     |                               |                              |                                | .2                          |
| Av.                  | .4                       | .1                         | 3.1                     | .1                               | .7                  | .2                  | .1                            | .05                          |                                | .03                         |
| <u>Sciaromium</u>    |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| <u>lescurii</u>      |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| LBCCXXIX             |                          |                            |                         |                                  |                     |                     | 7.4                           |                              |                                |                             |
| PoCCXI               |                          |                            | 1.5                     |                                  |                     |                     |                               |                              |                                |                             |
| P1CXLI               |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| P1CXLI               |                          |                            | 3.1                     |                                  |                     |                     |                               |                              |                                |                             |
| P1CXLI               |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| P1CXLI               |                          | 3.7                        |                         |                                  |                     |                     |                               |                              |                                |                             |
| P1CXLI               |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| Av.                  |                          | .3                         | .8                      |                                  |                     |                     | 2.5                           |                              |                                |                             |
| <u>Hygrohypnum</u>   |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| <u>luridum</u>       |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| MyCCXXXII            |                          |                            |                         |                                  | 1.9                 |                     |                               |                              |                                |                             |
| MyCCXXXIII           |                          |                            | 1.1                     |                                  | 1.8                 | .2                  |                               |                              |                                |                             |
| <u>Hygrohypnum</u>   |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| <u>ocraceum</u>      |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| SaCCXVII             |                          |                            |                         | 6.4                              | 5.0                 |                     | 2.1                           |                              |                                |                             |
| <u>Fontinalis</u>    |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| <u>antipyretica</u>  |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| var. <u>gigantea</u> |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| SaCCXV               |                          |                            |                         | 11.4                             |                     |                     |                               |                              |                                |                             |
| Undetermined         |                          |                            |                         |                                  |                     |                     |                               |                              |                                |                             |
| SaCCXIII             |                          |                            |                         | 4.1                              | .9                  |                     |                               |                              |                                |                             |
| SwCXCVII             |                          |                            |                         | 1.5                              |                     |                     |                               |                              |                                |                             |

| <u>Fontinalis</u><br><u>dalecarlica</u> | <u>Oxyethira</u> L | <u>Oxyethira</u> P | <u>Optioservus</u> sp. 1 A | <u>Ephemerella</u> catawba N | <u>Dixa</u> L | <u>Ephemerella</u> deficiens | <u>Nemoura</u> incl.<br><u>venosa &amp; sinuata</u> | <u>Microvelia</u> sp. | <u>Dubiraphia</u> A | <u>Pteronarcys</u> proteus N |
|-----------------------------------------|--------------------|--------------------|----------------------------|------------------------------|---------------|------------------------------|-----------------------------------------------------|-----------------------|---------------------|------------------------------|
| GicLIIB                                 |                    |                    |                            | 2.8                          |               |                              |                                                     |                       |                     |                              |
| GicLIII                                 |                    |                    |                            | 4.7                          |               |                              |                                                     |                       |                     |                              |
| JoCLXXII                                |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| ToCLX                                   |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| ToCCXLVI                                |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| SwCXCVI                                 | 1.5                | 1.1                |                            |                              |               |                              |                                                     |                       |                     |                              |
| SwCXCVIII                               | 2.7                |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| DicCCXXIII                              |                    |                    |                            |                              |               | 2.2                          |                                                     |                       |                     |                              |
| MuCXCV                                  | .1                 |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| MuCXCI                                  |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| LaCC                                    | 2.7                |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| LaCCI                                   | .3                 | .3                 | 1.7                        |                              |               |                              | .3                                                  |                       |                     |                              |
| HkCCIV                                  |                    |                    |                            |                              |               |                              | 18.7                                                |                       |                     |                              |
| HkCCII                                  | .5                 |                    |                            |                              |               | 2.5                          |                                                     |                       |                     |                              |
| SaCCXVI                                 |                    |                    |                            |                              |               |                              | 2.8                                                 |                       |                     |                              |
| SaCCXIV                                 |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| PoCCX                                   |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| PoCCVII                                 |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| PoCCVIII                                |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| MyCCXXXIV                               |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| MyCCXXXV                                |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| MyCCXXXVI                               |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| MyCCXXXVII                              |                    |                    |                            |                              |               |                              |                                                     |                       |                     | .2                           |
| MyCCXXXVIII                             |                    |                    |                            |                              |               |                              |                                                     |                       |                     | .5                           |
| MyCCXXXIX                               |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| MyCLIV                                  |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| MyCLV                                   |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| MyCLVI                                  |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| MyCLVII                                 |                    |                    |                            |                              |               |                              |                                                     |                       |                     |                              |
| MyCLVIII                                |                    |                    |                            |                              |               |                              |                                                     |                       |                     | 1.2L                         |
| Av.                                     | .4                 | .1                 | .1                         | .4                           |               | .3                           | 1.0                                                 |                       | .01                 |                              |

|                    | <u>Oxyethira</u> L | <u>Oxyethira</u> P | <u>Optioservus</u> sp. 1 A | <u>Ephemerella</u> catimba N | <u>Dixa</u> L | <u>Ephemerella</u> deficiens N | <u>Lemoura</u> spp. N | <u>Microvelia</u> sp | <u>Dubiraphia</u> A | <u>Pteronarcys</u> proteus N |
|--------------------|--------------------|--------------------|----------------------------|------------------------------|---------------|--------------------------------|-----------------------|----------------------|---------------------|------------------------------|
| <u>Scapania</u>    |                    |                    |                            |                              |               |                                |                       |                      |                     |                              |
| <u>undulata</u>    |                    |                    |                            |                              |               |                                |                       |                      |                     |                              |
| ToCLXII            |                    |                    | 3.8                        |                              |               |                                | 13.0                  |                      |                     |                              |
| ToCLIX             |                    |                    |                            |                              |               |                                |                       |                      |                     |                              |
| ToCLXI             |                    |                    | .5                         |                              |               |                                |                       |                      |                     |                              |
| ToCCXLI            |                    |                    | .5                         |                              |               |                                |                       |                      |                     |                              |
| ToCCXLII           |                    |                    |                            |                              |               |                                |                       |                      |                     |                              |
| ToCCXLIII          |                    |                    |                            |                              |               |                                |                       |                      |                     |                              |
| ToCCXLIV           |                    |                    |                            |                              |               |                                | .6                    |                      |                     |                              |
| ToCCXLV            |                    |                    | .2                         |                              |               |                                | .2                    |                      |                     |                              |
| HkCCV              |                    |                    |                            |                              |               |                                |                       |                      |                     |                              |
| HkCCVI             |                    |                    |                            |                              |               |                                |                       |                      | .7                  |                              |
| HkCCIII            |                    |                    |                            |                              |               |                                |                       |                      | .4                  |                              |
| LaCXCI             | .5                 | .3                 |                            |                              |               |                                | .3                    |                      |                     |                              |
| MuCXCI             |                    | 1.1                |                            |                              |               |                                |                       |                      |                     |                              |
| MuCXCI             |                    |                    |                            |                              |               |                                |                       |                      |                     |                              |
| MuCXCI             |                    |                    |                            |                              |               |                                |                       |                      |                     |                              |
| MuCXCI             | 2.7                | 1.8                |                            |                              |               |                                |                       |                      |                     |                              |
| Av.                | .4                 | .3                 | .2                         |                              |               |                                | .5                    |                      | .1                  |                              |
| <u>Hygroambly-</u> |                    |                    |                            |                              |               |                                |                       |                      |                     |                              |
| <u>stegium</u>     |                    |                    |                            |                              |               |                                |                       |                      |                     |                              |
| <u>fluviatile</u>  |                    |                    |                            |                              |               |                                |                       |                      |                     |                              |
| HyCCLI             |                    |                    |                            |                              |               |                                |                       |                      |                     | .4                           |
| HyCCXLVII          |                    |                    |                            |                              |               |                                |                       |                      |                     | 1.7                          |
| HyCCXLVIII         |                    |                    |                            |                              |               |                                |                       |                      |                     |                              |
| HyCCXLIX           |                    |                    |                            |                              |               |                                |                       |                      | .4                  | 1.7                          |
| HyCCLI             |                    |                    | 2.1                        |                              |               |                                | .7                    |                      |                     | 1.4                          |
| ElCLXXXVII         |                    |                    |                            |                              |               |                                |                       |                      |                     |                              |
| ElCLXXXVIII        |                    |                    |                            |                              | 1.8           |                                | .5                    |                      |                     |                              |
| ElCLXXXVIB         |                    |                    |                            |                              |               |                                |                       |                      |                     |                              |
| G1CLXVII           |                    |                    |                            | .7                           |               |                                | 1.5                   |                      |                     |                              |
| G1CLXIX            |                    |                    |                            | 2.0                          |               |                                |                       | .1                   |                     |                              |
| Av.                |                    |                    | .4                         | .4                           | .2            |                                | .1                    | .1                   | .03                 | .3                           |



|                    | <u>Rhyacophila invaria</u> L | <u>Caenis</u> N | <u>Neotrichia</u> L | <u>Neotrichia</u> P | <u>Paleagapetus celsus</u> L | <u>Paleagapetus celsus</u> P | <u>Micrasema</u> sp. 1 L | <u>Paragnetina</u> sp. N | <u>Chimarra aterrima</u> L | <u>Hydroptilid</u> gen. 1 L |
|--------------------|------------------------------|-----------------|---------------------|---------------------|------------------------------|------------------------------|--------------------------|--------------------------|----------------------------|-----------------------------|
| <u>Fontinalis</u>  |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| <u>dalecarlica</u> |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| G1CLIIIB           | .4                           |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| G1CLIII            |                              |                 | .3                  |                     |                              |                              | .6                       |                          |                            |                             |
| JoCLXXII           |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| ToCLX              |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| ToCCXLVI           |                              |                 |                     |                     | 1.0                          |                              |                          |                          |                            |                             |
| SwCXCVI            |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| SwCXCVIII          |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| DiCCXXIII          |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| MuCXCV             |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| MuCXCI             |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| LaCC               |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| LaCCI              |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| HkCCIV             |                              |                 |                     |                     |                              |                              |                          |                          |                            | 1.3                         |
| HkCCII             | .2                           |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| SaCCXVI            |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| SaCCXIV            |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| PoCCX              |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| PoCCVII            |                              |                 |                     |                     |                              |                              | 2.8                      |                          |                            |                             |
| PoCCVIII           |                              |                 |                     |                     |                              |                              | 1.9                      |                          |                            |                             |
| MyCCXXXIV          |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| MyCCXXXV           |                              |                 |                     |                     |                              |                              |                          | 3.0                      | 10.1                       |                             |
| MyCCXXXVI          |                              |                 |                     |                     |                              |                              |                          |                          | .6                         |                             |
| MyCCXXXVII         |                              |                 |                     |                     |                              |                              |                          | 1.4                      | 2.6                        |                             |
| MyCCXXXVIII        |                              |                 |                     | .1                  |                              |                              |                          | .5                       |                            |                             |
| MyCCXXXIX          |                              |                 |                     |                     |                              |                              |                          | 1.7                      | 1.0                        |                             |
| MyCLIV             |                              |                 |                     |                     |                              |                              |                          |                          |                            |                             |
| MyCLV              |                              | .5              | .2                  | .5                  |                              |                              |                          |                          |                            |                             |
| MyCLVI             |                              |                 |                     |                     |                              |                              |                          | .3                       |                            |                             |
| MyCLVII            |                              | 1.1             |                     | 3.3                 |                              |                              |                          |                          |                            |                             |
| MyCLVIII           |                              | 2.3             | .2                  | .2                  |                              |                              |                          |                          |                            |                             |
| Av.                | .03                          | .04             | .02                 | .4                  | .05                          |                              | .2                       | .07                      | .1                         | .06                         |

|                    | <u>Rhyacophila invaria</u> L |                 |  |                     |                             |                     |                             |                             |
|--------------------|------------------------------|-----------------|--|---------------------|-----------------------------|---------------------|-----------------------------|-----------------------------|
|                    |                              | <u>Caenis</u> N |  | <u>Neotrichia</u> L |                             | <u>Neotrichia</u> P |                             |                             |
|                    |                              |                 |  |                     | <u>Paleagapetus celus</u> L |                     | <u>Paleagapetus celus</u> P |                             |
|                    |                              |                 |  |                     |                             |                     | <u>Micrasema</u> sp. 1 L    |                             |
|                    |                              |                 |  |                     |                             |                     | <u>Paragnetina</u> sp. N    |                             |
|                    |                              |                 |  |                     |                             |                     |                             | <u>Chimarra aterrima</u> L  |
|                    |                              |                 |  |                     |                             |                     |                             | <u>Hydroptilid</u> gen. 1 L |
| <u>Scapania</u>    |                              |                 |  |                     |                             |                     |                             |                             |
| <u>undulata</u>    |                              |                 |  |                     |                             |                     |                             |                             |
| ToCLXII            |                              |                 |  |                     |                             |                     |                             |                             |
| ToCLIX             |                              |                 |  |                     |                             |                     |                             |                             |
| ToCLXI             | .5                           |                 |  |                     |                             |                     |                             |                             |
| ToCCXLI            |                              |                 |  |                     |                             |                     |                             |                             |
| ToCCXLII           |                              |                 |  |                     | .4                          |                     |                             |                             |
| ToCCXLIII          | .5                           |                 |  |                     |                             |                     |                             |                             |
| ToCCXLIV           |                              |                 |  |                     | .3                          |                     |                             |                             |
| ToCCXLV            | .2                           |                 |  |                     | 1.4                         |                     |                             |                             |
| HkCCV              | .3                           |                 |  |                     |                             |                     |                             |                             |
| HkCCVI             |                              |                 |  |                     |                             |                     |                             |                             |
| HkCCVII            |                              |                 |  |                     |                             |                     |                             |                             |
| LaXCIX             |                              |                 |  |                     |                             | .3                  |                             | .5                          |
| MuXCIV             |                              |                 |  |                     |                             |                     |                             | .6                          |
| MuXCII             |                              |                 |  |                     |                             |                     |                             | 2.1                         |
| MuXC               |                              |                 |  |                     |                             |                     |                             |                             |
| Av.                | .15                          |                 |  |                     | .1                          | .1                  |                             | .3                          |
| <u>Hygroambly-</u> |                              |                 |  |                     |                             |                     |                             |                             |
| <u>stegium</u>     |                              |                 |  |                     |                             |                     |                             |                             |
| <u>fluviatile</u>  |                              |                 |  |                     |                             |                     |                             |                             |
| HyCCLIII           |                              |                 |  |                     |                             |                     |                             |                             |
| HyCCXLVII          |                              |                 |  |                     |                             |                     |                             |                             |
| HyCCXLVIII         |                              |                 |  |                     |                             |                     |                             |                             |
| HyCCXLIX           |                              |                 |  |                     |                             |                     |                             |                             |
| HyCCLI             |                              |                 |  |                     |                             |                     |                             |                             |
| ElCLXXXVII         |                              |                 |  |                     |                             |                     |                             |                             |
| ElCLXXXVIII        |                              |                 |  |                     |                             |                     |                             |                             |
| ElCLXXXVIB         |                              |                 |  |                     |                             |                     |                             | .1                          |
| GicXLVII           |                              |                 |  |                     |                             |                     |                             |                             |
| GicXLIX            |                              |                 |  |                     |                             |                     |                             |                             |
| Av.                |                              |                 |  |                     |                             |                     |                             | .01                         |

|                                                                                                                                                                                                                       |  |     |  |     |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-----|--|-----|-----|
| <u>Rhyacophila invaria</u> L                                                                                                                                                                                          |  |     |  |     |     |
| <u>Caenis</u> N                                                                                                                                                                                                       |  |     |  |     |     |
| <u>Neotrichia</u> L                                                                                                                                                                                                   |  |     |  |     |     |
| <u>Nectrichia</u> P                                                                                                                                                                                                   |  |     |  |     |     |
| <u>Paleagapetus colus</u> L                                                                                                                                                                                           |  |     |  |     |     |
| <u>Paleagapetus colus</u> P                                                                                                                                                                                           |  |     |  |     |     |
| <u>Micrasema</u> sp. 1 L                                                                                                                                                                                              |  |     |  |     |     |
| <u>Paragnetina</u> sp. N                                                                                                                                                                                              |  |     |  |     |     |
| <u>Chimarra aterrima</u> L                                                                                                                                                                                            |  |     |  |     |     |
| <u>Hydroptilid</u> gen. 1 L                                                                                                                                                                                           |  |     |  |     |     |
| <u>Eurynchium</u><br><u>riparioides</u><br>G1CXLVIII<br>G1CL<br>G1CLI<br>G1CLIIA<br>G1CLIV<br>G1CLVI<br>HyCCL<br>HyCCLII<br>PoCCIX<br>RkCLXXXVIA<br>D1CCXXIV<br>D1CCXIX<br>D1CCXX<br>D1CCXXI<br>D1CCXXII<br>SaCCXVIII |  | 2.9 |  | 1.0 |     |
| <u>Sciaromium</u><br><u>lescurii</u><br>LBCCXXIX<br>PoCCXI<br>PiCCLI<br>PiCXLII<br>PiCXLIII<br>PiCXLIV                                                                                                                |  |     |  | 1.5 |     |
| <u>Hygrohypnum</u><br><u>luridum</u><br>MyCCXXII<br>MyCCXXIII                                                                                                                                                         |  |     |  |     |     |
| <u>Hygrohypnum</u><br><u>ocraceum</u><br>SaCCXVII                                                                                                                                                                     |  |     |  |     |     |
| <u>Fontinalis</u><br><u>antipyretica</u><br>var. <u>gigantea</u><br>SaCCXV                                                                                                                                            |  |     |  |     | 2.4 |
| Undetermined<br>SaCCXIII<br>SwCCXVII                                                                                                                                                                                  |  |     |  |     | .5  |
|                                                                                                                                                                                                                       |  |     |  |     | .8  |
|                                                                                                                                                                                                                       |  |     |  |     | 1.4 |
|                                                                                                                                                                                                                       |  |     |  |     | .8  |



TABLE XVI. DECEMBER COUNTS OF INSECTS PER GRAM DRY WEIGHT OF BRYOPHYTE

| Chironomidae L         | Prostimulum hirtipes complex L | Rapid sp. 1 L | Rhyacophila carolina L | Leuctra N | Palaegapetus celus L | Atherix variegata L | Hydropesche L | Nemoura incl. venosa & sinuata | Beetle Group 2 L | Cheumatopsyche L | Dilectrona modesta L | Isoperla billineata N | Nemoura vailicularia N | Taeniopterix N | Rhyacophila torva L | Promorpha elegans A |
|------------------------|--------------------------------|---------------|------------------------|-----------|----------------------|---------------------|---------------|--------------------------------|------------------|------------------|----------------------|-----------------------|------------------------|----------------|---------------------|---------------------|
| Fontinalis dalecarlica |                                |               |                        |           |                      |                     |               |                                |                  |                  |                      |                       |                        |                |                     |                     |
| MyCCCLXXXIII           | 219.2                          | 1.6           |                        |           |                      |                     | 5.9           |                                |                  | 3.2              | 2.2                  | 2.2                   |                        | .5             |                     | 1.1                 |
| MyCCCLXXXIV            | 53.2                           | .8            |                        |           |                      |                     | 3.0           |                                |                  | 1.6              | 1.1                  | 1.1                   |                        | .3             |                     | .6                  |
| Av.                    | 136.2                          | 1.2           |                        |           |                      |                     |               |                                |                  |                  |                      |                       |                        |                |                     |                     |
| Scapania undulata      |                                |               |                        |           |                      |                     |               |                                |                  |                  |                      |                       | 4.87                   |                |                     |                     |
| ToCCCLXXXV             | 134.8                          | 1.6           | 2.4                    | 12.4      | 5.2                  |                     |               | 3.2                            | 7.6              |                  |                      |                       |                        |                | 1.3                 |                     |
| ToCCCLXXXVI            | 61.7                           | 1.3           | 1.3                    | 20.2      | 7.6                  |                     |               | 1.3                            |                  |                  |                      |                       |                        |                |                     |                     |
| ToCCCLXXXVII           | 75.6                           | 2.4           | 4.8                    | 10.8      |                      | 1.2                 | 1.2           |                                |                  |                  |                      |                       |                        |                |                     |                     |
| ToCCCLXXXVIII          | 85.5                           | 1.8           | 3.6                    | 10.9      | 5.5                  | 1.8                 |               |                                |                  |                  |                      |                       |                        |                |                     |                     |
| ToCCCLXXXIX            | 88.3                           | 20.2          | 4.8                    | 5.8       | 5.8                  | .6                  | .2            | .9                             | 1.5              |                  |                      |                       | 1.0                    |                | .3                  |                     |
| Av.                    | 89.1                           | 1.2           | 3.3                    | 12.0      | 4.8                  |                     |               |                                |                  |                  |                      |                       |                        |                |                     |                     |

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