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SEASONAL DISTRIBUTION OF BENTHIC MACROINVERTEBRATES IN AN EASTERN PENNSYLVANIA TROUT STREAM[1]

PATRICIA T. BRADT

Department of Biology
Lafayette College
Easton, PA 18042

ABSTRACT

The benthic macroinvertebrate fauna were sampled biweekly at four stations for seventeen months. Two square feet were sampled at each station. The highest biomass, the highest number of individuals and the highest number of taxa were recorded during the summer months. The diversity index did not show any substantial seasonal fluctuation. Total numbers of macroinvertebrates, wet weight and total number of taxa were negatively correlated with the amount of rain and positively correlated with temperature and percent of oxygen saturation. Members of the family Hydropsychidae comprised 38.6% of the macroinvertebrate population, family Chironomidae 18.6% and order Ephemeroptera 16.0%.

INTRODUCTION

The Bushkill Creek in Northampton County supports a naturally reproducing brown trout (*Salmo trutta*) population, however the fish population is dominated by the white sucker, *Catostomus commersoni* (Bradt, 1). The members of the Salmonidae family have the most demanding environmental requirements of any fish family (Warren, 2). Therefore, any stream which can support a reproducing salmonid family popualtion must meet high chemical, physical and biological standards. Trout habitats have been rapidly disappearing from the United States and other countries due to the influence of man's activities on the drainage basins of these trout streams (Needham, 3).

The Bushkill Creek has a drainage basin of 79.2 square miles, the main streat course is 21.4 miles. The stream originates in the foothills of the Pocono Mountains and flows south easterly to its confluence with the Delaware River at Easton. The creek flows through woodland, farmland, suburban areas and the city of Easton. The stream receives agricultural, suburban and urban runoff in addition to industrial and domestic sewage effluents.

The stream is regularly stocked by the Pennsylvania Fish Commission because the intense fishing pressure cannot keep pace with the rate of natural reproduction. The stream has been designated a cold water fishery by the Pennsylvania Department of Environmental Resources.

In the upper part of the drainage basin the stream flows over shale and slate and runoff is rapid. In the lower part of the drainage basin the stream flows over limestone and runoff is slower (Young et al., 4). Water enters the stream from springs in lower part of the drainage basin. The pH of the stream rises as the stream enters the limestone area (Bradt, 1).

The macroinvertebrate benthic fauna (BMI) of the riffle areas of the Bushkill Creek were sampled. The BMI were chosen for sampling because they are relatively stationary, have comparatively long life cycles, and are therefore indicative of past environmental conditions (Gaufin, 5). Any alteration of environmental factors will be reflected in both the distribution and abundance of certain species, i.e., the composition of the community (Hynes, 6). Community composition and the diversity that it represents can be an extremely sensitive biological indicator of slight environmental changes (Warren, 2). When a factor becomes limiting, the more sensitive species are lost, competition is changed and organisms tolerant of a wide range of environmental conditions increase (Reid and Wood, 7). Clean water will support many different kinds of organisms and each species will be represented by only a few individuals and the diversity will therefore be high (Cairns and Dickson, 8). High diversity is correlated with the stability of the eco-system (Odum, 9).

The diversity index proposed by Cairns and Dickson (8) and adapted from information theory by Brillouin (10) was used to evaluate the diversity of the communities of BMI in the stream. The basic equation used is the Shannon (11) equation for determining the diversity of population samples. The formula is:

$$d = \frac{n_i}{n} \log_2 \frac{n_i}{n}$$

where d = diversity, n_i = number of individuals in the ith taxa, and n = total number of individuals.

The seasonal distribution of the various genera of BMI was also recorded in order to have a record of the dominant taxa in the stream at different seasons of the year.

MATERIALS AND METHODS

The BMI was sampled at four stations for seventeen months. The Surber Square Foot Sampler was used to sample the fauna in riffle areas (6 to 10 inches deep) in the stream (Surber, 12). The mesh size was nine threads per centimeter. Two square feet were sampled at each station. Sampling was done monthly in January, February and March and biweekly during the rest of the year. The sampling stations were distributed over 17.2 miles of the main stream course and the stations all had similar depths and substrates. Water quality was being monitored at the same time (1972 and 1973) so any severe water quality problems woudl have been noted (Bradt, 1). Two hundred twenty-five square feet of stream bottom were sampled over the seventeen months (May 1972 through September 1973).

The BMI were removed from the rocks with a stiff brush and flowed into the Surber net. On removal from the net the collected debris and BMI were placed in 70% ethyl alcohol for transportation to the laboratory, where the BMI were sorted, counted and identified using standard keys (Pennack, 13; Usinger, 14). Most individuals were classified to genus except the families Chironomidae and Elmidae.

Biomass was determined as wet weight in grams per square foot (Needham and Needham, 15). The number of individuals per square

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TABLE 1

Taxa of Benthic Macroinvertebrates Fauna-Percent of Total Numbers

	Jan. (8)*	Feb. (7)	Mar. (8)	Apr. (11)	May (32)	June (24)	July (31)	Aug. (31)	Sep. (37)	Oct. (15(	Nov. (14)	Dec (7)	Total # of Each Taxa	% of Total Nos. of Individ.
Order: Trichoptera														
Hydropsyche	14	18	8	15	12	12	33	24	26	27	23	22	14,363	28.5
Cheumatopsyche	16	7	4	4	3	3	7.5	10	14	15	19	11	5,082	10.1
Other Trichoptera[1]	4	4	1.5	4	3.5	7.5	10	7	7	13	9	8	2,974	6.0
Order: Diptera														
Chironomidae	9	30	40	22	33.5	41	18	10	9	7.5	10	4	9,351	18.6
Other Diptera[2]	7	5	11	10	6	4	4	7	5	6	8	4	2,797	5.5
Order: Ephemeroptera														
Baetis	8	8	7	1.75	4	4.8	4.3	4.5	6	5	1	7	2,612	5.2
Ephemerella	7	16	14	27	21	12	1.8	—	—	0.5	2	12	2,913	5.8
Other Ephemeroptera[3]	4	1	2	3	4.5	3	7.8	19	16	8	7	7	2,543	5.0
Order: Coleoptera														
Elmidae	12	5	5	4	3	4.8	5.8	7	8	9	12	12	3,013	6.0
Other Coleoptera[4]	6	4	1	3	2.5	3.0	3	2	2	1.5	2.5	3	1,015	2.0
Other Taxa														
Amphipoda: *Gammarus*	0.75	—	0.5	.75	—	—	—	0.5	0.25	1	—	—	218	0.4
Isopoda: *Ascellus*	1.5	—	1	—	—	0.75	—	1	0.5	0.25	0.75	0.75	390	0.8
Tricladia: *Dugesia*	0.75	—	—	—	—	—	—	—	—	1	1.5	—	310	0.6
Plecoptera	—	—	—	—	0.75	—	—	—	0.25	1	1.75	3	164	0.3
Other	10	2	5	5.5	6.25	4.2	4.8	8.0	6.0	4.25	2.5	6.25	2,660	5.3

*Number in parenthesis is number of square feet sampled that month.

Additional Numerous Genera

1. *Neophylax, Glossosoma, Psychomia, Neuroclipsis, Leucotrichia*
2. *Antocha, Simulium*
3. *Isonychia, Caenis, Pseudocloen, Stenonema*
4. *Psephenus*
5. Orders: Hemiptera, Lepidoptera, Megaloptera, Hydracarina, Decapoda
   Classes: Oligochaeta, Hirudinea, Gastropoda

foot and the number of taxa per square foot were also determined.

Diversity indices were calculated by the program of Cairns and Dickson (8) adapted for the Lehigh University Control Data Corporation 6400 Computer by James M. Parks, Ph.D. The numbers of each taxon (genus or family) were used in calculating the diversity indices. The calculated diversity index may therefore, be biased and slightly lower than an index calculated with the Elmidae and Chironmidae identified to genus.

Statistical analysis on water quality and BMI data was performed using the Lehigh Amalgamated Package for Statistics Program (Palchak and Koko, 16). Significant levels of correlations were calculated from the tables of Edwards (17).

RESULTS AND DISCUSSION

I. Benthic Macroinvertebrate Parameters

Figure 1 shows the monthly mean biomass in grams per square foot and the monthly mean total numbers of BMI individuals per square foot. The highest biomass for 1972 was recorded in June and for 1973 was also recorded in June. Biomass was lower in 1972 than in 1973 probably due to the high water associated with Hurricane Agnes in late June 1972 (Bradt, 18).

Total numbers of BMI per square foot were highest in October 1972 and July 1973. The peak in numbers in 1972 may have been delayed due to the scouring effect of the high water accompanying the hurricane (Allen, 19). Total numbers, biomass and number of taxa were negatively correlated ($p < 0.01$) with the amount of rain falling between sampling days (Bradt, 1).

Figure 2 shows the monthly variation in mean numbers of taxa per square foot and the mean diversity index per square foot. The highest number of taxa per square foot was recorded in August 1972 and August 1973. The number of taxa was lowest from December through April. Total number of taxa and total numbers of individuals were positively correlated ($p < 0.01$) with the percent of oxygen saturation, reflecting the effect of sufficient oxygen. Total numbers, biomass and number of taxa were positively correlated ($p < 0.01$) with temperature, reflecting the seasonal changes.

The diversity index showed less seasonal variations than the biomass, total numbers of individuals or number of taxa. The diversity index was lowest in February. Fewer number of square feet of stream bottom were sampled in the winter months in comparison with the other three seasons. Diversity was positively correlated ($p < 0.01$) with the number of taxa and negatively correlated ($p < 0.01$) with the total numbers of individuals. The diversity index appears to be a more sensitive indicator of the condition of the stream than either biomass or total numbers and less susceptible to seasonal fluctuation.

Table 1 shows the percentages and numbers of the predominating taxa of BMI found each month. The total number of BMI observed was 50,405. The order Trichoptera (class: Insecta) was the dominant order in the stream and comprised 44.6% of the total BMI population. Seventeen general of Trichoptera were found. The order Diptera (class: Insecta) comprised 24.1% of the BMI population (ten families) and the order Ephemeroptera 16% of total population (fifteen genera). The family Hydropsychidae was the most numerous family (38.6%) and the genus *Hydropsyche* the most numerous genus (28.5%). *Hydropsyche* has been noted as a dominant genus in several stream studies (Cummins et al, 20; Coutant, 21) and is reported by Usinger (14) to be abundant in California. These net spinning, omnivorous caddisflies are distributed world-wide and are especially plentiful where the current is fast and the water rich in particulate matter (Macan, 22; Hynes, 23). *Hydropsyche* is tolerant of a wide range of environmental conditions (Roback, 24) and appears

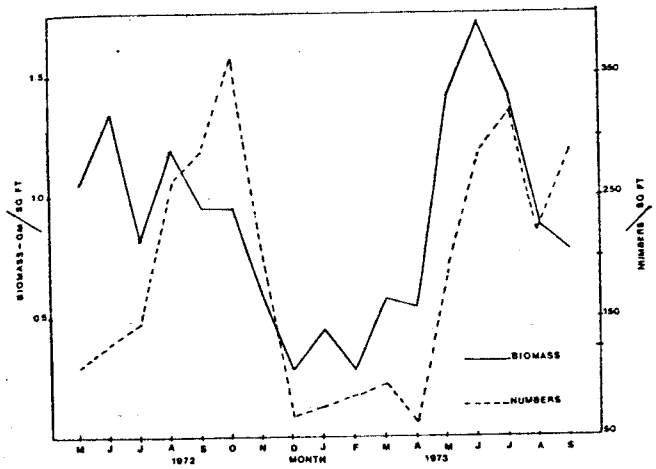

FIGURE 1. Benthic Macroinvertebrates - Monthly Mean Biomass (grams per square foot) and Monthly Mean Total Numbers of Individuals per Square Foot.

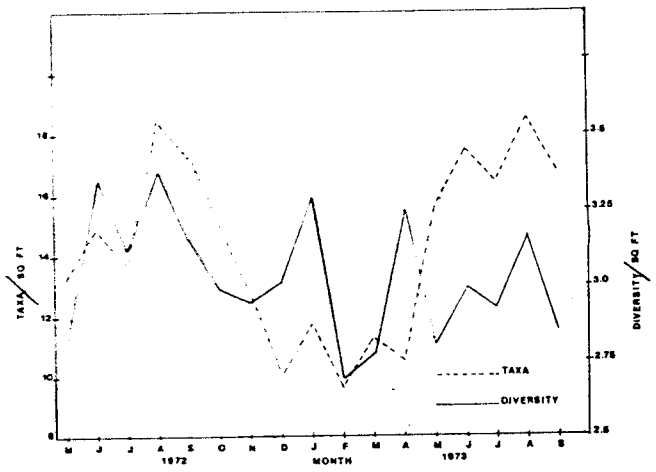

FIGURE 2. Benthic Macroinvertebrates - Monthly Mean Number of Taxa per Square Foot and Monthly Mean Diversity Index per Square Foot.

to be a tough competitor and a highly successful organism.

The range of the diversity indices is from 2.77 to 3.38. Wilhm and Dorris (25) suggest that diversity indices above 3.0 indicate clean water areas, while diversity indices between 1 and 3 suggest moderate pollution. Indices below 1 suggest areas of heavy pollution. The diversity indices suggest that the BMI of the Bushkill Creek are indicative of clean water, but is occasionally subjected to mild stress. Stress appears to be mainly from excess nitrates and phosphates from runoff and sewage effluents (Bradt, 1). Stress increases downstream and diversity decreases downstream. *Hydropsyche* becomes increasingly dominant as the stream approaches the Delaware.

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