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Substrate Preference of Benthic Macroinvertebrates in Silver Creek, Madison County, Kentucky

Catherine B. Crisp and Norman H. Crisp

Department of Biological Sciences, Eastern Kentucky University, Richmond, Kentucky 40475

Abstract

Field collections of benthic macroinvertebrates were taken with a square-foot Surber stream bottom sampler on 3 different types of substratum during August, September, and October 1973 on 4 occasions in order to determine the respective species diversity and percentage composition. The boulder substrate was the most productive, followed by the rubble, with sand and gravel the least productive. Thirteen orders and 20 genera of bottom organisms were identified, but a few genera made up the bulk of the standing crops for each station. *Stenonema* and *Isonychia* formed the majority of the ephemeropteran nymphs, *Cheumatopsyche* and *Hydropsyche* comprised over half the trichopterans, *Pentaneura* larvae accounted for most dipterans, and *Stenelmis* made up a large percentage of the Coleoptera. The data include prechannelization and postchannelization conditions. Standing crop for each station was similar before channelization, but afterwards the respective mean numbers declined.

Introduction

Substrate preference of macroinvertebrates was studied in a portion of Silver Creek, Madison County, near Richmond, Kentucky. Silver Creek is a permanent stream with a dendritic drainage pattern. Elevation at Station 1 is 210 m above mean sea level (msl). At Stations 2 and 3, the elevation is 204 m msl. Average gradient within the study area is 9.5 m/km. The 3 riffle stations selected for collection are all within fairly close proximity (0.64 km) of each other on Barnes Mill Road, Madison County. Physical characteristics for each station are shown in Table 1; the upstream and downstream boundaries for each station encompassed approximately 15–18 m.

Collections of aquatic macroinvertebrates were made on 4 occasions, 13 August, 1 September, 4 October, and 21 October 1972, at the 3 stations in an attempt to determine species density and percentage composition with respect to 3 different types of stream substrate. Substrates were considered as follows: boulders, rocks 30 cm or more in diameter; rubble, 7.5–30 cm; and sand and gravel, less than 7.5 cm. Other workers (Pennak and Van Gerpen 1947) used bedrock as a representative of the boulder type substrate, a type not investigated during this study.

During the week including 25 September, a portion of Silver Creek, involving Stations 2 and 3 was channelized. Therefore, the first 2 collections (13 August and 1 September) represent conditions prior to channelization, while the latter 2 (4 and 21 October) represent those after channelization.

Methods and Materials

A square-foot (0.093 m^2) Surber bottom sampler was utilized for taking quantitative samples. Three samples were taken from

TABLE 1.—SOME PHYSICAL PARAMETERS OF COLLECTION STATIONS IN SILVER CREEK

Parameters	Station 1 (boulder)	Station 2 (sand and gravel)	Station 3 (rubble)
Mean Velocity (m/sec)	0.54	0.20	0.67
Mean Depth (m)	0.12	0.09	0.21
Mean Width (m)	10.06	3.90	3.66
Channel Size (m^2)	1.18	0.36	0.77

each type of substrate on each visit, for a total of 36 samples during the study period. Sampling was random along the 15–18 m length and over the entire width of each station in order to minimize sampling errors caused by differences in production potential within each station. The benthos were counted and identified following the keys of Pennak (1953) and Ward and Whipple (Edmonson 1959), Burks (1953), Ross (1953), and Usinger (1956). Ephemeropteran nymphs in very early stages of development were too small for positive identification.

Channel size (Table 1) or area of cross section of stream basin, was calculated for each station, based on the formula $A = d_m - w$ (Reid 1961). Mean depths and velocity were determined with a Gurley current meter.

RESULTS

Ephemeropteran nymphs comprised the greatest percentage of the total number of benthos (Table 2) and were most abundant on the boulder substrate (53.51%), and least abundant on sand and gravel (8.69%, Table 4). Ephemeropteran nymphs were by far the most abundant benthic organisms on rubble, with an average percentage occurrence of 56.72 (Table 2). *Stenonema* was the most abundant genus in rubble but was scarce on sand. *Isonychia*, however, consistently occurred at moderate density on each substrate but was lower in overall abundance (Table 3). Four other genera (*Heptagenia*, *Caenis*, *Baetis*, and

TABLE 2.—AVERAGE PERCENTAGE OF THE FAUNA AND TOTAL DENSITY COLLECTED AT EACH STATION

Taxon	Station 1 (boulder)		Station 2 (sand and gravel)		Station 3 (rubble)	
	%	No.	%	No.	%	No.
Ephemeroptera	40.5	351	15.6	57	56.7	248
Trichoptera	17.2	149	19.4	71	23.5	129
Neuroptera	0.7	6	0.6	2	0.2	1
Diptera	6.1	53	3.8	14	4.2	23
Coleoptera	10.7	93	24.0	88	15.7	86
Plecoptera	0.2	2	0.0	0	0.4	2
Hemiptera	0.1	1	0.0	0	0.0	0
Odonata	0.4	3	0.0	0	0.7	4
Gastropoda	20.1	174	32.5	119	7.3	40
Pelecypoda	0.6	5	3.3	12	0.2	1
Isopoda	2.1	18	0.0	0	0.9	5
Decapoda	0.7	6	0.0	3	1.6	9
Turbellaria	0.7	6	0.0	0	0.0	0
Total		867		366		549
Mean no./m^2	6.71		3.75		4.25	

Paraleptophlebia) were present in smaller numbers at each station with the exception of *Paraleptophlebia* which occurred only on boulders.

Trichopterans, the second most abundant insect order were taken from all 3 substrates, being most abundant on boulders (Table 4) and least abundant on sand and gravel. At Station 3 (rubble), Trichoptera were the second most abundant taxa, averaging 23.5 percent of the total fauna (Table 2). *Cheumatopsyche* was the most abundant caddisfly, with a decreasing relative abundance from boulders to sand to rubble (Table 3). *Hydropsyche*, however, was most abundant on rubble, boulders, and sand, respectively. *Chimarra*, ranking third in trichopteran abundance, was found in fairly consistent numbers on each substrate. Both *Polycentropus* and *Diplectrona* were found on each substrate in small numbers only; however, their greatest density per square meter was on the boulder substrate.

Corydalus was the only representative of the order Neuroptera (Megaloptera) present, being most prevalent on boulders where the velocity was high, and least abundant on the sand and gravel substrate (Table 3). *Corydalus* accounted for only a small percentage of the total (Table 2).

TABLE 3.—MEAN NUMBER OF GENERA PER SQUARE METER ON DIFFERENT TYPES OF SUBSTRATE AT COLLECTING STATIONS

Taxon	Station 1 (boulder)	Station 2 (sand and gravel)	Station 3 (rubble)
Ephemeroptera			
Isonychia	1.07	0.38	0.51
Stenonema	1.23	0.03	0.90
Heptagenia	0.03	0	0.21
Caenis	0.16	0.03	0.22
Baetis	0.27	0.02	0.07
Paraleptophlebia	0.06	0	0
Trichoptera			
Hydropsyche	0.29	0.13	0.37
Cheumatopsyche	0.62	0.55	0.26
Chimarra	0.18	0.14	0.26
Polycentropus	0.05	0.01	0.01
Diplectrona	0.03	0.01	0.01
Neuroptera			
Corydalus	0.05	0.02	0.03
Diptera			
Pentaneura	0.11	0.39	0.17
Simulium	0.01	0.02	0.01
Coleoptera			
Psephenus	0.32	0.39	0.25
Stenelmis	0.39	0.28	0.34
Plecoptera			
Acroneuria	0.02	0	0.02
Hemiptera			
Platygerris	0.01	0	0
Odonata			
Argia	0.03	0	0.03
Gastropoda			
Pleurocera	1.31	0.92	0.33
Physa	0.03	0	0.03
Pelecypoda			
Sphaerium	0.04	0.10	0.01
Isopoda			
Lirceus	0.14	0	0.03
Decapoda			
Orconectes	0.04	0.03	0.04
Turbellaria			
Dugesia	0.04	0	0

Only 2 dipterans were found, both being most abundant on boulders (Table 3). *Pentaneura* was the most abundant, having a mean number of 0.1, 0.4, and 0.2 per square meter on boulders, sand and gravel, and rubble, respectively (Table 3). *Simulium* was present on all substrates but was most abundant on sand.

TABLE 4.—PERCENTAGE OCCURRENCE OF MACROINVERTEBRATE ORDERS AT EACH COLLECTING STATION

Taxon	Station 1 (boulder)	Station 2 (sand and gravel)	Station 3 (rubble)
Ephemeroptera	53.5	8.7	37.8
Trichoptera	42.7	20.3	37.0
Neuroptera	66.7	22.2	11.1
Diptera	58.8	15.6	25.6
Coleoptera	34.8	33.0	32.3
Plecoptera	50.0	0	50.0
Hemiptera	100.0	0	0
Odonata	50.0	0	50.0
Gastropoda	52.2	35.7	12.0
Pelecypoda	27.0	66.7	6.3
Isopoda	78.3	0	21.7
Decapoda	33.0	16.7	50.0
Turbellaria	100.0	0	0

The order Coleoptera was represented by 2 genera, *Psephenus* and *Stenelmis*, both being most abundant on boulders (Table 3). Both adults and larvae of *Stenelmis* were decreasingly abundant on boulders, rubble, and sand and gravel, respectively, whereas larval *Stenelmis* were more abundant than adults on sand.

Acroneuria, the only plecopteran found, was equally abundant on boulders and rubble, but lacking on sand and gravel.

Platygerris, the only hemipteran encountered, was collected at the boulder station only on 21 October 1972.

Argia, the only representative of damselflies collected, was equally distributed on boulders and rubble, but was absent from sand and composed only a small percentage of the total fauna.

Gastropods represented 20.07 percent of the fauna for the boulder substrate, 32.51 percent for sand, and 7.29 percent for rubble. These percentages were largely a result of the abundance of one snail, *Pleurocera*, which averaged 1.3, 0.9, and 0.3 per square meter on boulder, sand and gravel, and rubble, respectively. *Physa* was present on boulders and rubble in relatively low density, but was absent from the sand and gravel station.

The only pelecypod found, *Sphaerium*,

TABLE 5.—TOTAL AND MEAN BENTHIC STANDING CROP PER STATION (TWELVE SAMPLES WERE TAKEN FROM EACH STATION)

	Before Channelization				After Channelization			
	13 Aug		1 Sep		4 Oct		21 Oct	
	Total No.	Mean No./m²	Total No.	Mean No./m²	Total No.	Mean No./m²	Total No.	Mean No./m²
Station 1 (boulder)	132	4.09	180	5.58	239	7.41	317	9.83
Station 2 (sand and gravel)	130	4.03	186	5.75	—	—	44	1.36
Station 3 (rubble)	151	4.68	170	5.39	102	3.16	124	3.84

was decreasingly abundant on sand and gravel, boulders, and rubble, respectively.

Lirceus, an isopod crustacean, composed a very minute portion of the total fauna, being present only on boulders and rubble, most abundant on the first (Table 3). *Lirceus* appeared only in the last 2 collections following the decrease in water temperature.

Orconectes was less abundant on sand than on the boulder and rubble substrates, with the average percentage of the fauna being highest on the rubble substrate (Tables 2, 3).

At the boulder station, where the velocity was maximum, *Dugesia* was collected but was present only in the last 2 collections.

DISCUSSION

Although 13 orders and 20 genera of invertebrates were identified during this study, a few genera composed the bulk of the standing crops for each station. *Stenonema* and *Isonychia* formed the majority of the ephemeropteran nymphs. *Cheumatopsyche* and *Hydropsyche* comprised over half the Trichoptera. *Pentaneura* larvae accounted for most Diptera. *Stenelmis* made up a large percentage of the Coleoptera.

Standing crop for each station did not vary appreciably before channelization (Table 5). However, following channelization, the mean number of organisms per square meter declined while the standing crop for Station 1 (not channelized) increased (Fig. 1). A reasonable explanation for this rise in number for Station 1 is the occurrence of fall peaks in the life cycles of many of the insects. Most of the insects of streams have an annual turnover (Armitage 1958). Needham (1934) found the greatest seasonal abundance in both numbers and weight in May and a lesser peak of abundance in November during a mild winter. Maciolek and Needham (1951) reported an August low and a February high. Stehr and Branson (1938) reported the greatest density in the fall. This study was too limited in duration to indicate the seasonal course of the life cycles of the various species.

The varied habitat preferences for respective genera within reasonable sampling errors are evident from the data in Table 3. The baetid, *Isonychia*, for instance, is evidently better adapted, with its coxal gills and fringes of hair on the forelegs, to exist on varied substrates, while *Stenonema* (Heptageniidae) is less able to maneuver on sand, and prefers to cling to large flat rocks. As a group, the Ephemeroptera seemed to be adapted to a wider range of current speed and exposure in stream habitats than other insects collected. The trichopteran, *Cheumatopsyche*, exhibited an approximate 2:1 ratio in abundance over *Hydropsyche* within the same habitat. Interspecific competition probably is present between these species, *Cheumatopsyche* being better able to compete for available nutrients and space. Plecopteran nymphs were collected only from the surfaces of rubble and boulders where they were protected from abrasion and the swiftest current.

In viewing the total productivity of each substrate studied, the boulder substrate was the most productive followed by the rubble, with sand and gravel the least productive (Tables 2, 5, Fig. 2). The mean number of organisms per square meter was plotted against the median particle size of each substrate type and the regression line found using the criteria of Freund (1970). This indicated a positive correlation between mean number of organisms per square meter and substrate type. Since the coefficient of correlation (r) between the number of organisms and substrate types was 0.602 and the critical value for r is 0.611 (Freund 1970) at the 95 percent confidence level, it can be assumed that particle size is a determining factor in distribution of the benthos for the portion of Silver Creek studied. This is reasonable since boulders and rubble provided more space and more diverse habitats than a sand and gravel substrate.

Studies by Needham (1928, 1929, 1934), Behney (1937), Pate (1932, 1934), Pennak and Van Gerpen (1947), Percival and Whitehead (1929), and Sprules (1947) all concur with this study in indicating a higher standing crop in numbers on rubble than on gravel.

Following channelization of Stations 2 and 3 during the week of 25 September, there was a marked decrease in the fauna at those locations. This decrease can only be attributed to channelization since Station 1 did not show a similar decrease (Table 5, Fig. 1). Station 2 was drastically affected by channelization; however, a small-scale *t*-test demonstrated that there was a significant difference between surveys before and after channelization at Station 3.

This reduction of the fauna following habitat alteration is similar to that found by Meehan (1971) in Alaskan streams. Waters (1964), however, found that denuded bottom areas were often repopulated within 24 hours. Since he reported that drift was the most important factor in recolonization and drift is greater in fall, the communities of Stations 2 and 3 should have returned to the prechannelization level during the study period. Since the prechannelization density level was not reached in the relatively long section of the channelized stream, recolonization may have proceeded in a gradual manner down the length of the denuded stream. Thus, the portions of the stream in close proximity to the nonchannelized sections probably were rapidly recolonized, and areas farther from

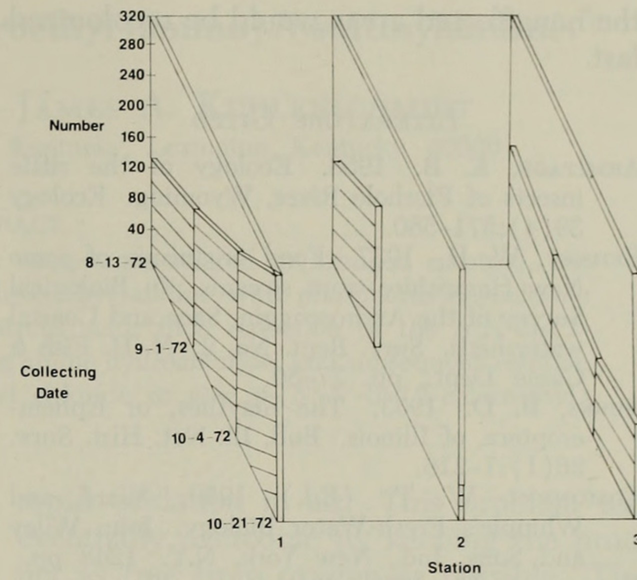

FIG. 1. Total number of benthos collected at each station on successive collecting dates.

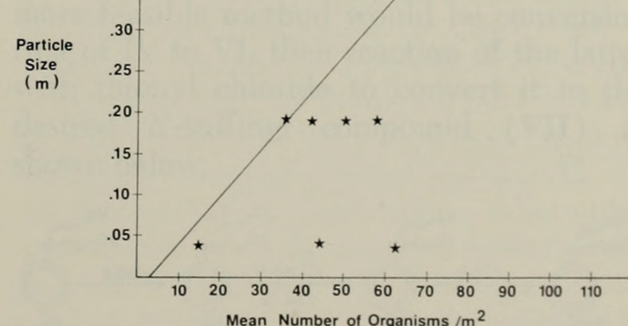

FIG. 2. Relationship between particle size and number of organisms per square meter.

the nonaffected areas would be recolonized last.

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