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Effects of artificial substrate on aquatic insect density were studied in Haines Branch, Lancaster County, Nebraska. Treatments consisted of small, medium, large, and mixed (mixture of small and medium) concrete substrates in modified basket samplers. Three replicates of each treatment were removed at 14 and 28 days and aquatic insects were then enumerated. Insects collected were chironomids (63%), mayflies (19%), caddisflies (15%), and beetles (3%). Mean mayfly densities, averaged over all substrate treatments, were higher on day 28 than on day 14, while the reverse was observed for chironomid densities. Mean densities for mayflies and chironomids were higher in medium and large than in small substrate samplers. Chironomid densities were higher in large substrate treatments versus medium and in uniform versus mixed substrate treatments. No significant treatment effects were found for the remaining taxa. It is concluded that neither substrate size nor heterogeneity are good predictors for insect densities in this stream.

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INTRODUCTION

The ecological characteristics of many species of aquatic insects are well documented and excellent reviews are provided by Hynes (1970) and Rosenberg and Resh (1984). Of particular importance is the role the substratum plays in determining species composition and distribution (Minshall, 1984). Several characteristics, including size, surface area, and heterogeneity have been shown to influence the number, density, or diversity of the species inhabiting a given substrate (Minshall and Minshall, 1977; Hart, 1978; Wise and Molles, 1979; Erman and Erman, 1984).

Many researchers have tried to control (or at least reduce) abiotic influences, with most of the approaches developed for high gradient, boulder, and cobble substrate water. Few studies have examined either the insect fauna or the influence of substrate on insect composition in low gradient, silt-bottom streams which drain intensively-farmed croplands. Further, the effect of silt on substrate selection by lotic insects has been inconclusive (Cummins and Lauff, 1969; Rabeni and Minshall, 1977).

A common feature of many silt-bottom streams and rivers is the presence of concrete slabs or blocks used for bank stabilization and that are considered a part of the lotic ecosystem. Thus, more researchers are employing artificial substrates (e.g., concrete) in aquatic experiments. Artificial substrates can also lead to more precise estimates of various parameters (Rosenberg and Resh, 1982).

The purpose of this study was to identify aquatic insects colonizing artificial substrates in an agriculturally-disturbed stream and to characterize the effects of different substrate sizes on insect density.

METHODS AND MATERIALS

Study site

Haines Branch is a small second-order stream in Lancaster County, Nebraska. Approximately 90% of its drainage is cultivated farmland. The experimental area was a single riffle, 15 m long, 5 m wide, and 17–30 cm deep. The substratum was relatively uniform, being composed primarily of sand and clay-silt sediments. Annual precipitation is moderate (average = 71 cm yr^{-1}), and the stream is subjected to periodic high flows and scouring during the spring and summer months.

Sampling methods

Replicate artificial substrate samplers were constructed of PVC pipe (3.81 cm deep x 7.62 cm wide) following a modification of the Hilsenhoff sampler (Troelstrup, 1985) and covered on the top by 6.5 mm coarse screen and on the bottom by 1 mm mesh screen. These were then secured to the stream bottom by attaching a metal rod to the back of the sampler and pushing the free end of the rod into the stream bottom. Artificial substrates used were constructed of concrete in three uniform cylindrical sizes (Table I). All samplers were placed on the bottom of the stream on 31 July 1985, at approximately the same depth (17–20 cm), and left to be colonized for 14 and 28 days. At the end of each sampling period, individual samplers were removed from the stream bottom and the contents preserved in 10% formalin. In the laboratory, samples were processed by washing the contents into a #60 U.S. standard sieve. Insects retained were hand-picked under a 10x dissecting microscope and identified to the lowest taxon possible. Estimates of mean density (number of individuals per square meter) were obtained. It was assumed that the inside of both top and bottom screens of the artificial samplers, as well as the interior, represented potential habitat and were included in the surface area calculations.

Statistical analysis

The treatment design was a 2 x 4 factorial with two levels of time (14 and 28 days) and four levels of substrate treatment (Table I). Previous work in this stream (Darrow, 1986) indicated varying location effects within a riffle; therefore, a randomized block design was employed, where location of samplers served as the blocking criterion. Three replicates were used per treatment/date combination.

TABLE I. Physical properties and treatment characteristics of artificial substrates used in Haines Branch, Lancaster County, Nebraska.

		Block			
Treatment	Block type	Mean diameter (cm)	Mean height (cm)	Number of blocks	Total area (m^2)
S	Small	1.27	1.27	34	0.05
M	Medium	2.20	1.80	10	0.04
L	Large	5.50	2.60	1	0.03
MS	Small			24	0.06
	Medium			10	

TABLE II. Insects collected from artificial substrate samplers in Haines Branch, Lancaster County, Nebraska.

Taxon	Total numbers
EPHEMEROPTERA	
Baetis spp.	286
Caenis sp.	84
Heptagenia diabasia Burks	118
Stenonema integrum (McDunnoough)	6
TRICHOPTERA	
Hydropsyche betteni Ross	135
Cheumatopysche spp.	264
COLEOPTERA	
Carabidae	6
Dubiraphia quadrinotatum (Say)	65
Dytiscidae	1
ODONATA	
Coenogrionidae	2
DIPTERA	
Chironomus spp.	450
Cricotopus spp.	618
Dicrotendipes sp.	62
Tanytarsus sp.	119
Thienemannimyia gr. sp.	256
Thienemanniella sp.	155

Fixed-effects linear models were employed for testing specific hypotheses, including analysis of variance (ANOVA) and mean comparison tests. All analyses were subjected to verification of normality (Shapiro-Wilk statistic; Ray, 1982) and homogeneity of error variances (Bartlett's Test; Steel and Torrie, 1980). All computations were performed using the Statistical Analysis System (SAS) (Ray, 1982). Tests for normality and homogeneity of error variance were rejected ($p.<.10$); therefore, a transformation, log (density), was used to normalize the data. Orthogonal contrasts were used to delineate treatment differences: average of uniform sizes (S, M, and L) versus mixed sizes (MS); small (S) versus the average of medium (M) and large (L); medium versus large. The level of rejection of the null hypotheses was $p = 0.10$.

RESULTS

Experimental conditions

No major perturbations were observed during the study that would have altered the integrity of the treatments. All samplers remained relatively free of silt and detritus. Some periphyton were observed on the surface of the substrates and, though not quantified, appeared to be sparsely distributed. Water temperatures during the study period were 19–23°C while dissolved oxygen was 8.45–11.80 mg/l.

Community composition

A total of 2,627 individuals representing sixteen taxa were collected during this study (Table II). Chironomids made up the majority of species collected (63%), with predominant taxa being *Cricotopus* spp. and *Chironomus* spp. Mayflies comprised 19% of the total, with *Baetis* spp. predominant, while caddisflies made up approximately 15%, with *Cheumatopsyche* spp. predominant. The majority of species collected can be classified as collector-gatherers (Merritt and Cummins, 1984), feeding on detritus and plant materials deposited in the stream and sampler. However, predatory taxa, *Coenagrionidae* and *Thienemannimyia* spp., were also present.

Substrate effects

Individuals were classified into four major taxonomic groups for analysis: Ephemeroptera (mayflies), Hydropsychidae (caddisflies), Coleoptera (beetles), and Chironomidae. These four groups comprised over 90% of the community and were considered representative of this stream. Density patterns are presented in Figure 1.

Two-way ANOVA revealed no significant ($p.<.10$) interactions between substrate treatment and sampling date; thus, mean densities for all treatments remained consistent over time, for all four taxonomic groups. Utilizing location of the samplers as a potential source of variation in the design was effective in that all analyses, with the exception of that for Coleoptera, revealed a significant ($p.<.10$) block effect.

Mean densities of Ephemeroptera (Fig. 1), averaged over all substrate treatments, were higher on day 28 than on day 14 (6.45 vs. 5.98; $p.<.10$), while mean densities for Chironomidae (Fig. 1), averaged over all substrate treatments, was lower on day 28 than day 14 (7.28 vs. 7.65; $p.<.10$). Mean densities for Hydropsychidae and Coleoptera (Fig. 1), were not significantly different between the two sampling dates. Mean densities of Ephemeroptera and Chironomidae, averaged over both time periods, were lower ($p.<.10$) in the small substrate treatments (densities of 6.03 and 7.35, respectively) versus the medium and large substrate treatments combined (6.49 and 7.66, respectively) while these substrate treatments had no effect on Hydropsychidae or Coleoptera mean densities. Mean densities of Chironomidae, averaged over both time periods, were higher ($p.<.10$) in large substrate treatments versus medium (7.91 vs. 7.41) and in uniform versus mixed substrate treatments (7.56 vs. 7.18). However, no significant differences were observed in these same substrate treatments for any of the other three groups.

DISCUSSION

The results of this study indicate that under relatively uniform experimental conditions, the effect of substrate on aquatic insect density varied depending on the taxonomic group. No consistent relationship between substrate and density was observed.

The finding that only two groups were affected by substrate treatment indicates that, in general, the aquatic insects of Haines Branch are not distributed simply based on substrate size. Since the results were based on standardized area, any significant density differences observed among treatments were due to substrate size and/or heterogeneity. In all cases of significant density differences, the mixed-substrate treatment, which had the greatest heterogeneity, had lower average densities than the other treatments. It is concluded that this mixed substrate provided a less desirable environment than that of the uniform substrates. Although this conclusion conflicts with those of Allan (1975) and Wise and Molles (1979), it adds support to the conclusions of Erman and Erman (1984) that heterogeneity did not yield any significant effects on insect density. Neither were insect densities significantly affected by substrate size. If size were an important criterion, then densities should change linearly from the small to the large samplers. None of the groups analyzed exhibited this pattern. Thus, substrate size alone is not an important factor affecting the aquatic insects in this stream. This conclusion supports that of Minshall (1984).

The increase of Ephemeroptera but decrease of Chironomidae with increasing time may be a result of suitability of the substrates to mayfly colonization, particularly in the medium and large substrate-samplers. However, chironomid densities were distributed similarly over the treatments and thus some other phenomenon may be present such as a shift in the age structure and availability of insects for colonization. It may also be that the observed results reflect the normal changes in fauna over time in this stream. Though statistically significant differences were observed, the numerical differences in mean densities were very similar. Thus, the taxa observed may not be substrate-selective. If they were, they would not exist in such great numbers as were found in this silt-bottom stream.

It is apparent that insect density is not easily predicted by substrate size alone. Factors such as food availability and sediment loading should be taken into consideration, particularly in habitats similar to that found in this study. Though siltation was not considered a factor in the present study, previous work (Darrow, 1986) showed that siltation can potentially influence aquatic insect distribution in this stream. Thus, problems presented by agriculturally-disturbed streams are not the same as those studied by the majority of researchers in high gradient, boulder streams and warrants further research.

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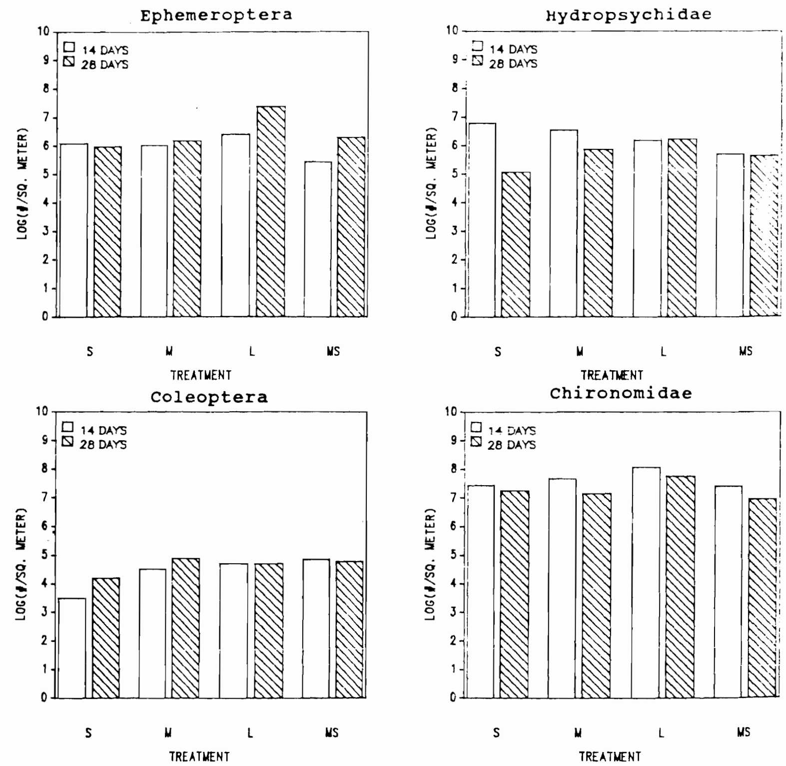

FIGURE 1. Density patterns for insects colonizing artificial substrates in Haines Branch, Nebraska. S=small substrate; M=medium; L=large; MS=mixed substrate.

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