THE EFFECTS OF REDUCED INCIDENT LIGHT ON FOUR STREAM INSECTS OF TENDERFOOT CREEK, MICHIGAN

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ABSTRACT

The population densities of four aquatic insect species, Hydropsyche bifida, Hydropsyche morosa, Cheumatopsyche sp., and Baetis sp., were monitored during a seven week period from June to late-July to measure the effects of decreased incident light on Tenderfoot Creek (Gogebic Co, MI). Species population densities were recorded and are analyzed on a time sequence as well as on the basis of experimental treatment.

Screens were used to selectively reduce the incident light over 500 square centimeters of stream comprising the experimental treatment. The colonization trays beneath each shaded treatment were filled with cleaned stream rocks. Control as well as clean control treatments were used for standards of comparison. Insects were collected biweekly by thorough underwater scrubbing and collection into drift nets.

Results of the experiental treatment show significant differences in aquatic insect densities on the basis of time. Presumed declines in photosynthetic production in shaded areas resulted in declining population trends of Baetis sp., and stable populations of the three caddisflies. The difference in populations due to shaded conditions were not found to be significant.

Possible reasons for the insignificance of the data are: inadequate shading provided by the aparatus, inadequate numbers of samples included in the analysis, or true independence of lighting variables. Population densities of these four species are shown to be dependent upon time.

INTRODUCTION

A common classification of aquatic insects taken from Cummins and Klug (1979) is based on feeding methods and basic anatomical differences. The four suggested groups include shredders, filter feeders, scrapers and deposit collectors. Filter feeders spin nets in which to catch detritus and other organic matter. Shredders are equipped with cutting jaws to break down terrestrial leaves and scrapers are capable of removing algae and other detritus from solid surfaces. The fourth group, deposit-collectors, have reduced mouthparts and feed only on organic matter of the sediments. Ideally, one should investigate the interactions of all four groups (Lamberti 1984); their ecological niches commonly overlap, especially under altered environmental circumstances.

Increased or decreased canopy over a stream area, such as that caused by logging or by the downfall of leaves in autumn, can greatly impact the benthic community. To imitate a natural decrease in incident light, shaded colonization trays were built as experimental instruments of this research project. Based on knowledge of the insect community, the initial hypotheses were as follows: No change in populations was expected to take place in the filter-feeders, since they rely on detritus floating through the water column. For example, insects populations of *Hydropsyche bifida* Banks, *Hydropsyche morosa* Hagen, and *Cheumatopsyche sp*. should not be affected by the decreased light. A marked decline in the population of scrapers should be observed, however, since their food supply of photosynthetic algae should not proliferate under the shaded conditions. The scraper observed in this study was *Baetis* *sp*.

The expected results are easily predicted from the knowledge that invertebrate microdistribution patterns are often based solely on abundance of food (Rabeni and Minshall 1977). With this in mind, we can expect secondary changes based on food abundance to result within the insect populations as well. For example, an overall decrease in filter feeders could eventually result from predator-prey interactions. Predators such as stoneflies may begin to prey upon filter feeders as soon as scrapers have been eliminated from the area (Townsend and Hildrew 1976).

MATERIALS AND METHODS

Initial investigation of the stream area included a preliminary population count of the aquatic insects. Five surber samples were taken from random areas of Tenderfoot Creek, including both lower and upper riffle areas. Identification was to species where possible (Hilsenhoff 1981; Merritt and Cummins 1984; Schuster and Etnier 1978).

Colonization trays used for the experiment were built according to specifications such that each tray was 500 cm2 in area. For the shading device, a wooden apparatus was built around this tray such that the four legs stand about 0.5 m. tall. Black gardeners mesh was cut at the stream site such that all sides of the apparatus including the top were covered. The mesh was cut and stapled to the apparatus allowing no more than a centimeter uncovered near the water level.

Substrate used for colonization in the three treatments are as follows: Control trays used uncleaned stream rocks, clean control used cleaned stream rocks, and shaded used cleaned stream rocks. Rocks were "cleaned" of attached insects and algae with rough scrubbing with hands.

The trays were placed in the stream at a somewhat random order. Most were initially at depths of at least 30 cm. The six shaded trays along with their controls were initially placed in the stream on 6/13/89: three of these were removed on 6/25/89. These comprise the Time 1 series. A fourth tray was removed on 7/10/89. This, along with a set placed in the stream from 6/25/89 to 7/17/89, comprises a Time 2 series. The two unaccounted sets from 6/25/89 were not used due to severe decrease in water level and the apparent dislodgement of the apparatus from experimental site.

RESULTS

The results of the preliminary population study indicate the insects' relative consistency throughtout the stream bed. Five of the most abundant insects found in the five samples were evaluated for their mean population size and standard deviation from the mean. These results appear in Table 1. (Crude results of the entire preliminary population survey from 6/29/89 appear in Table 2.) Greatest populations at this time were in the family Hydropsychidae. These are considered as scrapers in the feeding group divisions. Also abundant are the Baetidae Baetis sp., which form the feeding group of scrapers. Dipterans of the family Simuliidae also are abundant.

Statistical analysis allowed us to estimate the number of samples necessary to insure that random variation does not bias a population sample. Although some insects, such as Chimarra sp. were evenly distributed in all five samples and only required 3 samples, some of the insects chosen for further study were much less desirable in this regard. For example, the results suggested a minimum of 49 samples were needed for a subsample of Hydropsyche sp. with 0.05 significance and 80 percent avoidance of type II error, as shown in Table 1.

The first experimental samples taken from the stream (Time Series 1), show a high abundance of Cheumatopsyche, followed by Hydropsyche morosa, and Hydropsyche bifida. There were various other species of Hydropsyche, including H.

bronta Ross, H. sparna Ross, H. slossonae Banks, and H. betteni Ross; however, their populations were sparse and inconsistent throughout the stream. They will not be considered in this study. Baetis sp. were relatively abundant and were consistently found in all samples. Thus, from these first three sample sets, four species were chosen to be followed through the course of the summer: H. morosa, H. bifida, Cheumatopsyche sp., and Baetis sp. Crude data from all samples is shown in Table 3.

Three sample sets remained in the stream to be considered as four week samples. Due to a gradual decrease in water level, one of the sets which had been in approximately 30 cm deep water was now in only a few cm. of still standing water. These conditions were so unlike the other experimental conditions in terms of depth and current, that their results were disregarded. The other sample set was unusable as it was upturned by the water current. A later sample set of 6/25-7/17/89 was added to comprise Time Series 2.

Of Time Series 2, H. bifida were the most abundant at densities much higher than those found in Time Series 1. (See Figure 1) H. morosa were also much more abundant in the later sample dates of July. There were no evident changes in the populations of Baetis sp. or Chematopsyche sp. over time. Table 4 shows the significant differences measured in the populations over time in H. bifida, and H. morosa: two-way analysis of variances indicate $p<0.005$ for H. bifida and

$p<0.005$ for H. morosa. The populations of these species show marked increases in density in July, as compared to June. On the other hand, Cheumatopsyche sp. showed a slight decrease in population density during the later sampling periods of July, although this was not seen as significant by method of analysis of variance.

Other qualitative changes in density over time were those of the family Simuliidae. On 6/29/89, they were present in populations of 7 per ft2 (see Table 2). At the collection of the second sample sets on July 10, however, there was at least a one hundred-fold increase in population density as they literally covered our samples with their grey color. By the time the last sample was collected on July 17, however, there were very few left in the stream.

As far as density differences according to experimental treatment, none was seen as significant using an analysis of variance. There are slight differences in densities that can be noted, however. First, the density in the control group is higher in all four studied species than in that of clean control and shaded treatments. Second, although it is not identified as significantly different, the Baetis sp. population is much more abundant in the control and in the clean control groups than in the shaded group. These densities are 11.3 (per 500 cm2) and 9.6 respectively, and 2.0 in the shaded treatment as shown in Figure 2.

The p-value for the Baetis sp. population in respect of treatment is 0.145, indicating insignificant differences from the other treatments. The other p-values for the species populations by treatment are indicated in Table 5. It is to be noted that the considerations of treatment ignore any time series; that is, all densities are lumped together on the basis of treatment without regard to time.

DISCUSSION

The preliminary population sample indicated organisms which were present in abundance on that sample date. This, however, did not ensure that these same organisms would be present throughout the sample time. Several organisms such as those in the family Simuliidae were eliminated from the study, as they were expected to emerge at some unknown time during the study. Other organisms such as Chironomidae were eliminated due to the difficult task of identifying them to species. Most other organisms were found so infrequently in a sample, that their use would be severely limited due to lack of adequate data. Based on the previous research done on Tenderfoot Creek (McTigue 1988), and the criteria previously mentioned, four species were chosen as subjects for this study.

Unfortunately, due to the difficulties of studying a constantly changing stream environment, the organisms which were appropriately qualified for study did not conveniently fall into all four feeding group categories. The organisms present only allow for a comprehensive study of scrapers and filter feeders. None of the common insects fit the definition of predator, thus the predator-prey interaction could not be investigated in terms of the struggle for food availability. The effects of decreased light affects filter feeders and scrapers in remarkably different ways, and thus they themselves afford the research sufficient data.

Huge increases in population densities occur in relation to time in the genus Hydropsyche. There could be several reasons for this positive corrolation: more larval forms may actually be present in the warmer waters of mid-summer, or the data may represent an oversight of the smaller forms in the earlier sample dates. Collection errors could have resulted in the smaller forms being inadvertently left in the nets or on the rocks themselves. The negative correlation of population density to time in Cheumatopsyche sp. is likely due to the actual emergence of mature forms.

Without any respect to treatment, differences would be expected on the basis of substrate and level of recolonization in the three treatments. Initially, it was planned that a tray of untouched rocks would be used for the control. This is a rather poor control for the shaded treatment, however, since this used rocks which were cleaned before allowing recolonization. Since the control substrate did not require a recolonization period, their densities were possibly inflated for this reason alone. Therefore, all comparisons are additionally made to clean controls as they appear to be more legitimate measures of treatment differences.

It is possible that the lack of significant difference between the control densities and shaded densities could be due to inadequate shading technique. When the shaded apparatuses were initially placed in the stream, the water level was 5-7 inches higher than its height at the end of the end of the sampling period. Since the dark mesh was cut around the frame when the water level was high, large areas of frame, (including the colonization trays) were exposed to incident light beyond ideal conditions of complete blockage. With this in mind, it is possible that the shading did not ellicit the predicted effect due to the inadequacies of the experimental conditions.

Also, due to the time constraints involved in processing numerous samples, a limited number of sample trays were placed throughout the stream. At the initial time of placement, groups of the three treatments were placed in similar habitats of depths, and current. While these could easily be compared to each other, the random variation which occurs even at close distances does not allow for their serious consideration as data points. Instead, it was necessary to group all data from each treatment in order to achieve sufficient data to be used in statistical analysis. This is a legitimate action, as the individual trays were randomly placed, without respect to treatment.

The population differences in treatments, although not demonstrating significant differences, show gradual trends that support the initial hypothesis. In the category of filter feeders, *H. bifida*, *H. morosa*, and *Cheumatopsyche sp.*, there appear to be nearly equal populations in all three treatments. These treatments demonstrate neither positive nor negative effects on the abundance of these filter feeders. The shaded treatments had nearly equal numbers of these organisms as the control treatments, which is an expected result considering their constantly "imported" food supply from upstream areas.

In the population of the group of scrapers studied, Baetis sp., the populations are unequally distributed in the control groups. It appears that the shaded treatment was not a conducive habitat for the survival of Baetis sp., while it was well inhabited by the Hydropsychidae family. This supports the argument regarding food availability as the primary factor involved in organizing microhabitats of invertebrates. Baetis sp. are evidently dependent on photosynthetic algae, as it is the primary determinant in the survival of this species in the shaded treatments. Thus, while not producing statistically significant results, the underlying data trends appear to reaffirm the feeding group classifications and the hypothesis that scapers would be affected by a decrease in incident light while the filter feeders would not be affected.

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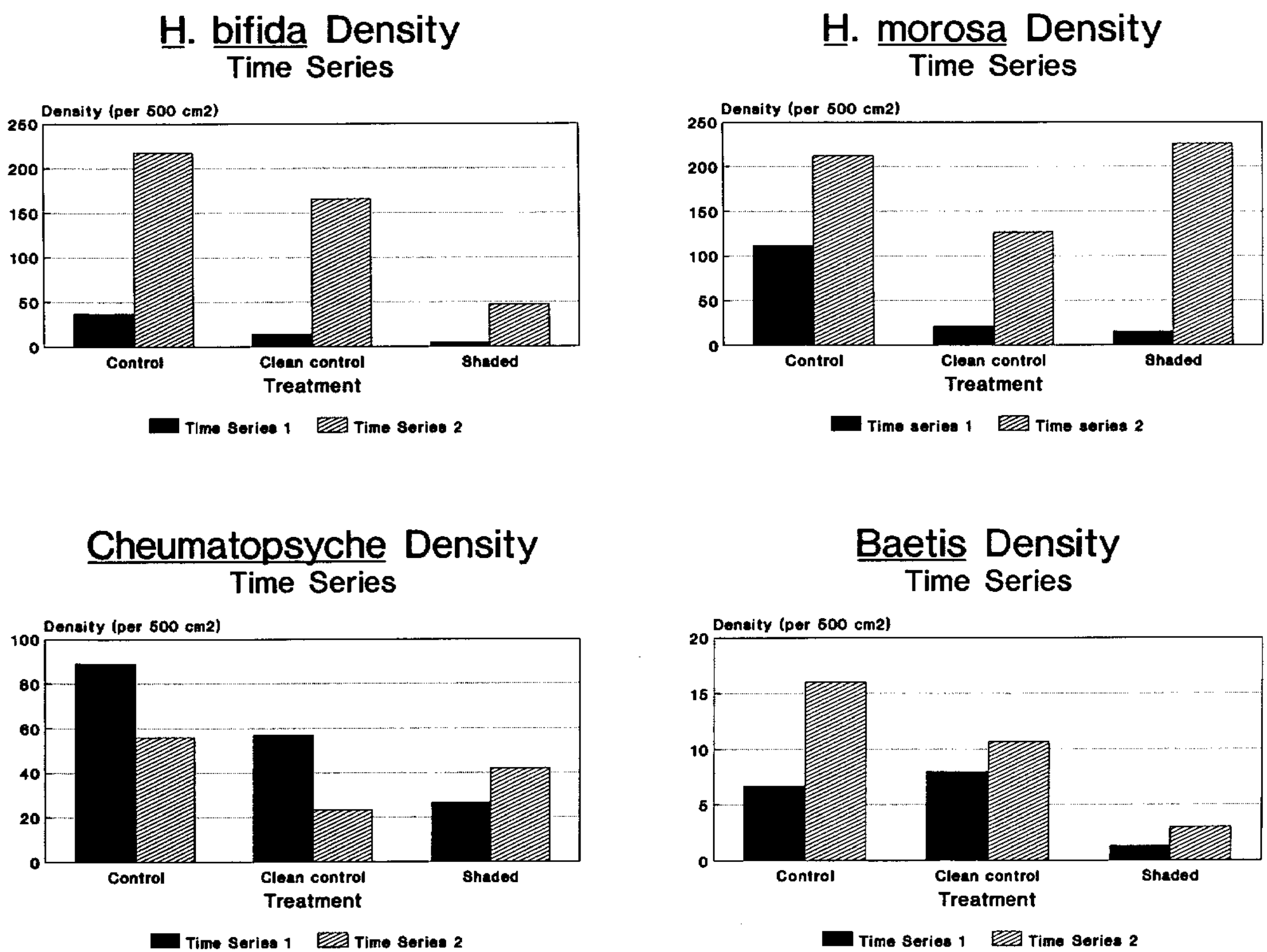

FIGURE 1: Species Density by Time Series of Four Aquatic Insects Inhabiting Tenderfoot Creek

Time Series 1==June 13 to June 25, 1989
Time Series 2==June 25 to July 17, 1989

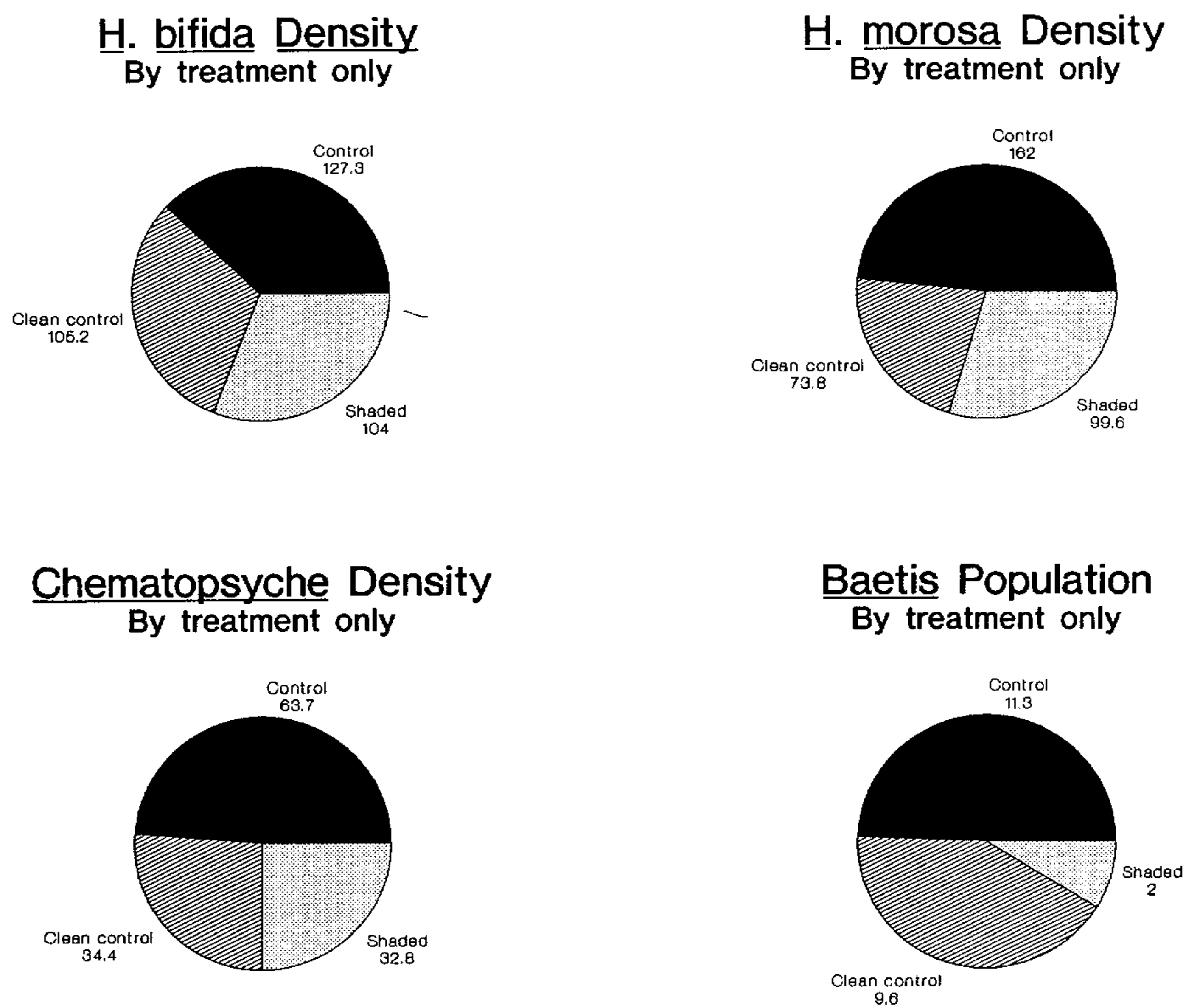

FIGURE 2: Species Density by Treatment Over Entire Sampling for Four Aquatic Insects Inhabiting Tenderfoot Creek (June 13 to July 17, 1989)

TABLE 1: Preliminary Population Density Data for the Five Most Populated Aquatic Insects in Tenderfoot Creek (Computed to a 0.05 level of significance and an 80 percent probability of detecting a Type II error)

Organism	Mean Density (per 500 cm2)	Standard Deviation	# of samples
Hydropsyche sp.	46.0	21.5	49
Cheumatopsyche sp.	60.4	14.9	8
Baetis sp.	30.4	12.4	13
Simuliidae sp.	7.0	3.8	3
Stenonema sp.	1.4	0.9	0

Table 2: Crude results of preliminary population densities (from Surber samples taken of Tenderfoot Creek 6/29/89)

Organism	Samples 1	2	3	4	5	MEAN
Hydropsyche betteni	1	17	7	10	2	7.4
Hydropsyche bifida	5	17	13	10	1	9.2
Hydropsyche morosa	11	93	17	22	2	29.0
Cheumatopsyche	22	107	55	79	39	60.4
Baetidae *Baetis*	3	76	17	32	24	30.4
Philopotamidae *Chimarra*	0	8	2	15	2	5.4
Simuliidae	1	20	1	11	2	7.0
Chironomidae	3	12	8	6	1	6.0
Chironomidae *Chronomini*	2	0	0	0	0	0.4
Perlidae *Isoperla*	1	0	0	0	0	0.2
Heptageniidae *Stenonema*	0	1	5	0	1	1.4
Psychomyia flavida	1	1	3	1	1	1.4
Gomphidae *Ophiogomphus*	1	0	0	0	1	0.4
Limnephilidae pycnopsyche	0	0	1	1	0	0.4
Limnephilidae hydatophylax	0	1	0	0	0	0.2
Helicopsyche	0	0	1	0	0	0.2
Elmidae *Stenelmis*	0	0	1	0	0	0.2
Polycentropus	0	0	1	0	0	0.2

Table 3: Crude insect densities in Tenderfoot Creek per 500 cm2 sample colonization tray with stream rock substrate

Shaded Treatment

	Sampling Dates				
	6/13-6/25			6/13-7/10	6/25-7/17
Organism	1	2	3	1	1
Hydropsyche betteni	0	1	0	0	0
Hydropsyche bifida	0	7	6	287	220
Hydropsyche morosa	5	24	17	284	168
Hydropsyche sparna	0	0	0	0	0
Hydropsyche slossonae	0	0	0	0	0
Hydropsyche bronta	0	1	2	0	4
Cheumatopsyche	30	34	16	24	60
Baetidae *Baetis*	2	1	1	3	3
Philopotamidae *Chimarra*	0	0	0	0	4
Heptageniidae *Stenonema*	1	1	0	2	5

Control treatment

	6/13-6/25			6/13-7/10	6/25-7/17
Organism	1	2	3	1	1
Hydropsyche betteni	10	2	15	0	0
Hydropsyche bifida	32	18	62	250	158
Hydropsyche morosa	121	17	198	270	104
Hydropsyche sparna	0	0	1	0	0
Hydropsyche slossonae	1	0	2	0	0
Hydropsyche bronta	8	0	4	4	2
Cheumatopsyche	154	35	34	56	18
Baetidae *Baetis*	5	8	7	27	5
Philopotamidae *Chimarra*	2	0	1	0	0
Heptageniidae *Stenonema*	0	0	0	1	4

Clean Control Treatment

	6/13-6/25			6/13-7/10	6/25-7/17
Organism	1	2	3	1	1
Hydropsyche betteni	0	1	0	2	5
Hydropsyche bifida	4	15	14	144	113
Hydropsyche morosa	3	20	40	142	42
Hydropsyche sparna	0	0	0	0	0
Hydropsyche slossonae	0	1	0	0	0
Hydropsyche bronta	0	1	1	0	3
Cheumatopsyche	18	57	45	34	8
Baetidae *Baetis*	3	16	0	18	2
Philopotamidae *Chimarra*	0	1	0	0	1
Heptageniidae *Stenonema*	0	0	0	0	5

TABLE 4: P-values from Two-way Analysis of Variance for Species Density Over Time

	Mean Density (per 500 cm2) Time Series 1	Time Series 2	D.F.	P-value
Hydrpopsyche bifida	18.722	143.459	1	0.000*
Hydropsyche morosa	49.443	188.222	1	0.002*
Cheumatopscyhe sp.	57.666	40.443	1	0.200
Baetis sp.	5.333	9.889	1	0.237

*significant difference p <0.005

TABLE 5: P-values from Two-Way Analysis of Variance for Species Density per Treatment

	Mean Density (per 500 cm2)				
	Control	Clean control	Shaded	D.F.	P-value
Hydropsyche bifida	127.3	105.2	104.0	2	0.295
Hydropsyche morosa	162.0	73.8	99.6	2	0.138
Cheumatopsyche sp.	63.7	34.4	32.8	2	0.256
Baetis sp.	11.3	9.6	2.0	2	0.145