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DIVERSITY OF E.P.T. TAXA IN RELATION TO LAND USE ALONG GREAT TROUGH CREEK

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ABSTRACT

The purpose of our study was to determine to what extent stream-side land use affected Ephemeroptera, Trichoptera, and Plecoptera (E.P.T.) species diversity and abundance within Great Trough Creek in Huntingdon County, Pennsylvania. We compared three distinct areas, an agricultural area, a recreational area, and a forested area. According to the Simpson's Diversity Index, the forested site supported the greatest diversity of E.P.T., followed by the recreational and finally the agricultural land use area. The abundance of E.P.T. was lower at the agricultural site than the recreational and forested sites, which had similar abundances. These results suggest that E.P.T. diversity and abundance decrease with increasing human impact.

Keywords: Ephemeroptera, Great Trough Creek, land use, Plecoptera, Trichoptera.

INTRODUCTION

Stream systems can be directly impacted by surrounding land use and also the disruption of the streambed itself. Macroinvertebrates, such as the insect orders Ephemeroptera, Plecoptera and Trichoptera (E.P.T. taxa), may be affected by these land-use strategies. By comparing the diversity of E.P.T. taxa in agricultural, recreational, and forested areas along Great Trough Creek in central Pennsylvania, we attempted to "determine whether poor water quality or degraded habitat are stressing the invertebrate communities" (Resh *et. al.*, 1995).

In the recreational area we predicted that direct human physical impact on the stream would occur, such as streamside picnicking, swimming, and waste disposal in the stream. We also predicted that the agricultural area would be the recipient of chemical runoff, and that factor would diminish the E.P.T. populations the most. The forested area we used as a control, where direct human impact was minimal and chemical runoff was not a factor.

According to McTammany and Benfield (1998), macroinvertebrate diversity decreases as urbanization increases. Therefore, we hypothesized that the forested area would hold the highest diversity and abundance of E.P.T. organisms, the agricultural area would have the lowest diversity, and the recreational area would fall somewhere in between.

FIELD SITE

We chose Great Trough Creek in Huntingdon County, Pennsylvania (Fig. 1) as our study site because three distinct land-use areas (agricultural, forested, and recreational) could be identified while keeping physical factors relatively constant. The agricultural area was immediately downstream of tributaries draining livestock and crop fields. The forested area was approximately 1 km downstream from the agricultural area, and received no direct input from human-based runoff. The recreational area was approximately 2 km downstream of the forested area, and was situated beside a picnic pavilion and heavily trafficked tourism site.

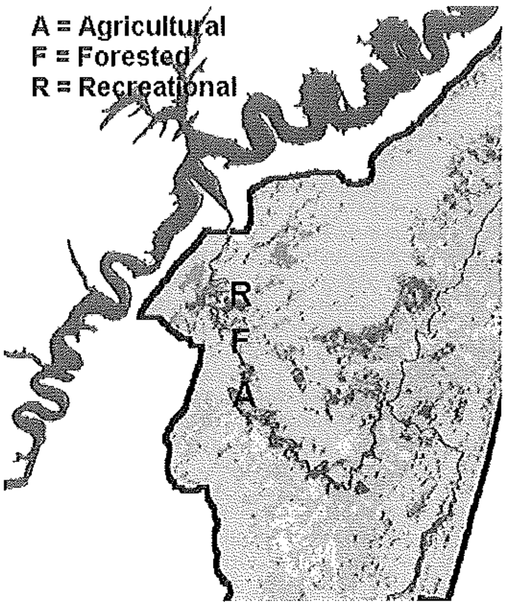

Figure 1. Great Trough Creek watershed. Areas sampled are indicated with capital letters R, F, and A. These letters represent the recreational site, the forested site, and the agricultural site, respectively. Creek flow is towards the north, or the top, of the figure, where it empties into Raystown Lake.

METHODS AND MATERIALS

On March 22, 2000 we conducted an initial survey of Great Trough Creek and chose three areas from which to collect data. We attempted to keep the sites as similar as possible in regards to plant cover, substrate, and dimensions, but differing in streamside land-use practices. The first site we chose was the agricultural site, which was the farthest upstream site of those sampled. We chose this site because it was located directly downstream of a tributary draining livestock pastures and crop fields. The next site we chose was the forested area. We chose this site because of its seclusion within the hemlock and hardwood forest and distance from the road. The third site we chose was the recreational area that was located adjacent to a public picnic pavilion and beach area in Trough Creek State Park.

In each of the three sites, a 15-m length of stream was marked using a measuring tape. We then mapped this length on paper and gridded it into 30 sections, 10 sections long and three sections wide. Using a random numbers table, we selected 10 of the 30 sections for macroinvertebrate sampling. We also randomly measured depth with a meter stick, width with a measuring tape, and flow rate using a float, a timer, and a meter stick. We then calculated the averages of those three parameters, and also multiplied the three measurements to calculate discharge. We attempted to disturb the stream as little as possible.

We also took a number of chemical measurements of the water at each of the test sites on the same dates we sampled for macroinvertebrates. We measured the temperature, pH, dissolved oxygen content, and the conductivity of the water at the site using the appropriate meters. We took water samples back to the lab on ice and tested for nitrates and phosphates using HACH spectrophotometers and the factory-prescribed procedures.

On March 25, 2000 we sampled for macroinvertebrates at the agricultural area. In the center of each of the previously chosen sections, we set the benthic sampler (Fig. 2) on the substrate, disturbed the area within the bucket, and allowed the stream to flow through the screen pushing the sediment-laden water through the net, thereby trapping the macroinvertebrates. We started sampling with the sections farthest downstream, so as to not disturb other sampling areas. We repeated the process on April 1, 2000 for the remaining two sites.

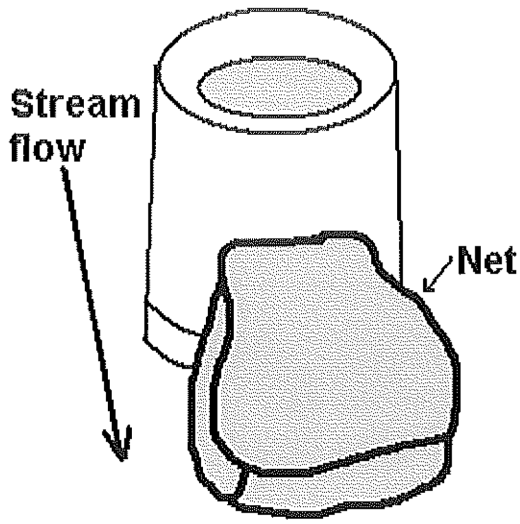

Figure 2. Benthic Sampler. Water flows through screen on far side of sampler (not shown) and pushes sediment-laden water through the net. Substrate is disturbed manually through the top hole.

We collected the specimens in buckets containing water from the sample site. We transported these back to the lab and kept them refrigerated until time allowed for identification. We identified to family and counted all the E.P.T. organisms using pans, forceps, dissecting scopes, and field guides. Using that data, we calculated Chi-square values (using Minitab software) between the sites to find if there were significant differences in the diversity and abundance among the sites. We also used Simpson's diversity index to compare relative diversities of the E.P.T. organisms among the three sample sites.

RESULTS

Each of the three test sites was chosen because they shared similar physical characteristics (Table 1). The water chemistry of the forested and recreational areas were also very similar, but the agricultural area had a higher pH, conductivity, and nitrate concentration, and lower temperature and dissolved oxygen concentration (Table 2). All three streams had the same phosphate concentration. Counts of Ephemeroptera, Trichoptera, and Plecoptera are displayed in Table 3. The numbers of Ephemeroptera and the total number of organisms differed significantly among the three sites (χ^2 = 18.197 and 24.613, respectively, $P < 0.001$; Table 4). Finally, the Simpson's Diversity Index was highest in the forested area and lowest in the agricultural area (Table 5).

Table 1. Physical characteristics of each of the three test sites. Values given are averages of the 15-m spans of stream sampled.

	Agricultural	*Forested*	*Recreational*
WIDTH (m)	6.19	8.25	18.525
DEPTH (cm)	15.3	23.6	22.7
FLOW RATE (m/sec)	0.305	0.6125	0.55
DISCHARGE (m^3/sec)	0.289	0.1193	0.231
SUBSTRATE	50% Cobbles 48% Silt 2% Boulders	65% Boulders 30% Cobbles 2% Sand 2% Silt 1% Gravel	80% Cobbles 11% Gravel 5% Boulders 2% Sand 2% Silt
MACROPHYTIC COVERAGE	Streamside: Hemlock In Stream: Moss, Grass	Streamside: Hemlock, Rhododendron, Deciduous Trees, Shrubbery In Stream: Grass	Streamside: Hemlock, Rhododendron, In Stream: Grass

Table 2. Chemical characteristics of each of the three sites. Values are point measurements.

	Agricultural	**Forested**	**Recreational**
pH	6.18	5.9	5.89
CONDUCTIVITY (μS)	108	52	50
WATER TEMP (° C)	10.5	11.2	11.8
DISSOLVED 0_2 (ppm)	11.2	12.8	12.5
NITRATES (mg/L)	0.5	0.2	0.2
PHOSPHATES (mg/L)	0.02	0.02	0.02

Table 3. Biological characteristics of each of the three sites. Values given are total numbers of each family from each sampling site.

	Agricultural	**Forested**	Recreational	
EPHEMEROPTERA				
Leptophlebiidae	19	55	62	
Siplonuridae		6	7	
Oligoneuriidae		1		
Heptageniidae			1	
PLECOPTERA				
Leuctridae			6	
Perlodidae	1	8	1	
Nemouridae		1		
TRICHOPTERA				
Limnephilidae	2	12	4	
TOTAL Ephemeroptera	19	62	70	**151**
TOTAL Plecoptera	1	9	7	**17**
TOTAL Trichoptera	2	12	4	**18**
TOTAL # ORG'S	22	83	81	**186**

Table 4. Comparisons of numbers of E.P.T. organisms among the three test sites using Chi-square goodness-of-fit tests.

	EPHEMEROPTERA	PLECOPTERA	TRICHOPTERA	TOTAL
CHI-SQUARE	18.197	3.344	4.40	24.613
DEGREES OF FREEDOM	2	2	2	2
P-VALUE	0.000	0.188	0.111	0.000

Table 5. Simpson's diversity index at the three test sites.

AREA	D-VALUE
AGRICULTURAL	1.322
FORESTED	2.016
RECREATIONAL	1.745

DISCUSSION

We found significant differences in the abundance of E.P.T. organisms between the agricultural site and the forested and recreational sites, the last two of which were similar. This difference in total numbers of E.P.T. organisms was most affected by the abundance of Ephemeroptera, which was also significantly different between the agricultural site and the forested and recreational sites (Table 3).

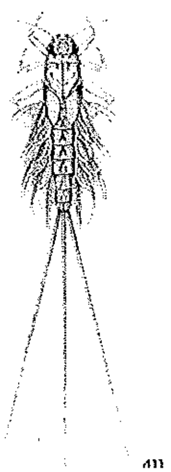

Figure 3. Adult Ephemeroptera (mayfly) of the family Leptophlebiidae. This family was the most common in our samples.

The nitrate concentration and ion conductivity of the agricultural site were higher than those of the recreational and forested sites, which were the same. This is as expected due to the agricultural runoff. This may have contributed to the low diversity or abundance of the taxa in that area.

The forested area had the highest family diversity, followed by the recreational area, and then the agricultural area. These results supported our hypothesis that macroinvertebrate abundance and diversity should change in response to land use. These results also correspond with those of McTammanky and Benfield (1998) who suggested that the diversity of benthic invertebrates should decrease as urbanization increases.

Future studies are needed to clarify and advance our findings, including testing similar nearby streams using the same methods in order to compare the effects of land-use. This work may reveal other factors that affect E.P.T. diversity and abundance. Furthermore, it would be worthwhile to conduct tests at different times of the year to take into account seasonal changes in land use, such as increases in tourists and agricultural fertilization during the warmer months.

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