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BIOTIC INDEX, CONDUCTIVITY, AND BIOLOGICAL OXYGEN DEMAND IN THREE LOCAL STREAMS

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ABSTRACT

The water quality of three stream sites in Huntingdon County, Pennsylvania was estimated by three measures: a biotic index based on macroinvertebrate abundance, ionic conductivity, and biological oxygen demand.

Keywords: biological oxygen demand, biotic index, conductivity, macroinvertebrates, streams, water quality

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INTRODUCTION

Natural springs and streams are an important source of clean water for both animals and humans alike. Animals living in polluted streams are less abundant and species diversity may be lower than that of non-polluted streams (Barbour et al. 2001). Animals and humans that obtain their drinking water from polluted streams may have mild to serious health problems. To calculate a "biotic index" of water quality, macroinvertebrate abundance was estimated at three different sites including Muddy Run, Emma Spring, and Ell Spring, located in Huntingdon County, Pennsylvania. Both Muddy Run and Emma spring are subject to human pollution either from agriculture as in Emma's case or storm water run off and littering in the case of Muddy Run. By testing the water of the streams and calculating a biotic index for each, we aimed to determine whether the presence of human pollution is affecting the water quality of these streams. We hypothesized that Ell Spring should have the highest biotic index, Emma should have the second highest index, and that Muddy Run would have the lowest index.

SITE DESCRIPTIONS

The water entering Ell Spring originates from a large, deep aquifer, and thus its flow is largely unaffected by rain and drought. The spring is located in a forested area that appears to be unaffected by human pollution and as a result the water in the spring should be free from pollutants associated with agricultural run-off and other human wastes.

Emma Spring is located in an agricultural area. The source of the water supplying this spring is probably not very deep because it was observed to have a higher flow rate during periods of rain. This spring is within a steep ravine surrounded by large trees.

Muddy Run is a stream that runs through Juniata College and is subject to multiple human made pollution. Muddy Run is greatly affected by rain and runoff from the streets and parking lots that surround the college. The stream is surrounded on all sides by shrubs and grasses.

METHODS AND MATERIALS

At each of the three sites, pH and conductivity were measured using electronic meters. Maximum and minimum water temperatures during a 24-h day were estimated at each site using max-min thermometers. Collection of species for the biotic index was done by drawing out a map of each site and dividing that map into grid areas. The areas were then numbered and a random numbers table was used to select the grid area in which to obtain a sample, using a core sampler. Five samples from each site were taken. Macroinvertebrates were later counted and identified in the laboratory using taxonomic keys. The number of animals of each taxon collected at each site was used to calculate a biotic index of water quality at that site (following Anonymous 1999). This index weights the abundance of taxa according to their sensitivity to pollution.

RESULTS

The biotic index of each stream tended to be inversely correlated with conductivity ($r^2 = 0.9684$, $P = 0.114$) and biological oxygen demand ($r^2 = 0.9549$ $P = 0.136$), although neither association was significant (Figs. 1 & 2). Table 1 shows the number of organisms of various macroinvertebrate taxa collected at each site, as well as the total number collected and the calculated biotic index). Table 2 shows the various physical measurements taken at each site.

Table 1. Number of individuals of various taxa collected at each of the three study sites, as well as the calculated biotic index for each site.

	Ell Spring	Emma Spring	Muddy Run
Taxa			
Amphipods	22	178	0
Trichoptera	8	15	0
Tipulidae	3	3	1
Fontigens nickliniana	133	0	0
Empididae	1	0	0
Chironomidae	1	9	0
Ephemeroptera	1	0	9
Planaria	0	6	0
Oligochaeta	0	0	14
Leech	0	0	3
Gyrinidae	0	0	1
Lymnaeidae	0	0	1
Copepod	0	0	1
Plecoptera	0	0	1
Totals	169	211	30
Biotic Index	**344**	**428**	**53**

Table 2. Physical measurements taken at each of the three study sites.

Physical Data

Spring	pH	Conductivity	Biological Oxygen Demand (mg O_2/mL)	Temperature Max/Min (°C)
Muddy Run	7.54	436	0.7	18.5/13.0
Ell Spring	7.58	260	0.31	9.0/8.5
Emma Spring	6.76	148.9	0.03	10.0/9.0

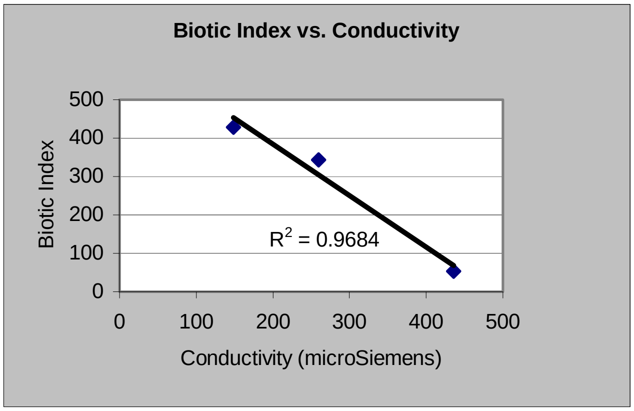

Figure 1. Association between the biotic index and the conductivity of the water at each of three stream sites.

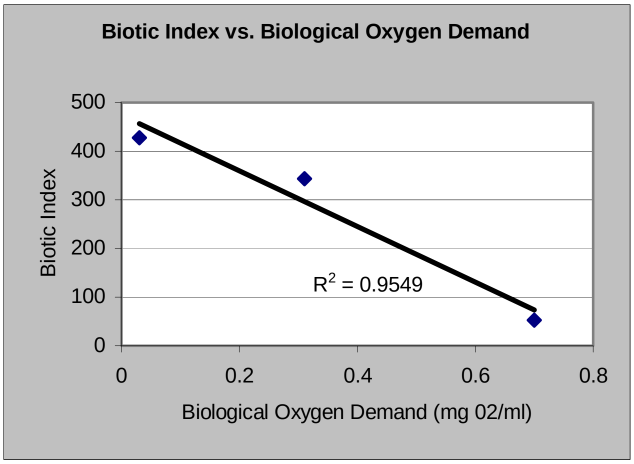

Figure 2. Association between the biotic index and the biological oxygen demand of the water at each of three stream sites.

DISCUSSION

Our prediction was partly correct in that Muddy Run had the lowest biotic index. However, Emma Spring had a higher biotic index than Ell Spring. The biotic index seems to be affected by both the biological oxygen demand and conductivity, as there is a strong (but nonsignificant) correlation between these measurements and the biotic index. Another factor that may have an effect on the macroinvertebrate life are the maximum and minimum temperatures. Muddy Run has a significantly higher temperature than both Ell and Emma Spring, which may have affected the abundance of various invertebrates living there.

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IS SQUIRREL FORAGING ACTIVITY ASSOCIATED WITH TEMPERATURE?

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ABSTRACT

Eastern gray squirrel (*Sciurus carolinensis*) foraging activity during early spring has been shown to vary throughout the day according to air temperature. We hypothesized that squirrel foraging activity should be highest in the morning when temperatures are lowest, and that foraging should be lower in the afternoon when temperatures are highest. We found that there is a negative correlation between temperature and foraging activity (r = -0.413, P = 0.036). Our data suggest that foraging activity is highest in the morning and at low to moderate temperatures.

*Keywords: Eastern gray squirrel (*Sciurus carolinensis*), foraging, temperature*

INTRODUCTION

The eastern gray squirrel (*Sciurus carolinensis*) has a distribution covering most of the eastern half of the United States, from eastern Texas to the Atlantic Coast (MacClintock 1970), including areas where temperatures are relatively moderate compared to those of the arctic and the tropics. The Eastern gray squirrel is a generalist species, capable of inhabiting a wide variety of habitats and eating a variety of foods (Halloran 1999). However, they prefer habitats with hardwood trees and primarily feed on hardwood nuts, seeds, fungi, insects, and fruits (Burt 1976). Studies conducted on squirrel foraging behavior discovered peak foraging activity in the morning about 2 hours after sunrise and about 2-5 hours before sunset (Halloran 1999). One reason for this bimodal activity may be that temperatures are more moderate during morning and evenings. If foraging activity is focused at these times rather than the afternoon, exposure to extreme temperatures is minimized (Bryce 2001).

In this study we examined whether eastern gray squirrel foraging depends on temperature. We hypothesized that afternoon foraging activity should be less than foraging activity in the morning or evenings.

Since the eastern gray squirrel is a generalist species, understanding their foraging patterns may contribute to an overall understanding of generalist species' behavior. Foraging behavior may also explain squirrel distribution patterns. If squirrels forage during cooler temperatures this might limit them to areas with moderate temperatures, such as in temperate areas.

METHODS AND MATERIALS

Eastern gray squirrels were studied in a patch of hardwood trees that line a field behind the Brumbaugh Science Center at Juniata College, Huntingdon, Pennsylvania. Beyond the study site is a residential area. Roasted, unshelled peanuts were scattered on the ground in a restricted area about 4 x 2 m in size once a day for one week before observations began so squirrels would discover the food source. Foraging activity was observed for 10 d (between April 1-18, 2002) at 3 different times during each day: morning (8am - 9am), afternoon (1pm - 2pm), and evening (6pm - 7pm). Daylight savings time occurred after the fifth day of observation so observation times were adjusted accordingly. After daylight savings time, morning observations were from 9am - 10am, afternoon observations from 2pm - 3pm, and evening observations from 7pm - 8pm. Data collected from 9am - 10am, 2pm - 3pm, and 7pm - 8pm were included with data collected from 8am - 9am, 1pm - 2pm, and 6pm - 7pm, respectively. We quantified foraging activity as the number of squirrels that captured a peanut in the feeding area. Squirrels that remained at the food site and gathered more than 1 peanut were counted only once.

Temperature (^{o} C) was recorded at 20-minute intervals during the hours of observation designated above, and the mean temperature for each hour was calculated. Observers stood at a distance from the feeding area in order to decrease interference with squirrel foraging. A chi-square goodness of fit test was used to determine if there is a difference in squirrel foraging at different times of the day and at different temperatures. To determine if overall temperature is associated with squirrel foraging activity, correlation analysis was used. Null hypotheses were rejected at $P < 0.05$.

RESULTS

Number of squirrels observed at different times of the day differed significantly from expected values ($\chi^2 = 112.677$, df = 1, $P < 0.001$; see Table 1). Observed number of foraging squirrels at different temperatures differed significantly from expected values ($\chi^2 = 48.4516$, df = 1, $P < 0.001$; see Table 2). Squirrel foraging activity was significantly inversely correlated with temperature ($r = -0.413$, $P = 0.036$; see Figure 1).

Table 1. Observed and expected frequencies of numbers of squirrels foraging at different times of the day.

Time of day	Observed	Expected
morning (8-9am)	79	31
afternoon (1-2pm)	14	31
evening (6-7pm)	1	31

Table 2. Observed and expected frequencies of numbers of squirrels foraging at different temperatures throughout the day.

Temperature (^{o} C)	Observed	Expected
low (3-15)	56	31
moderate (16-28)	37	31
high (29-41)	2	31

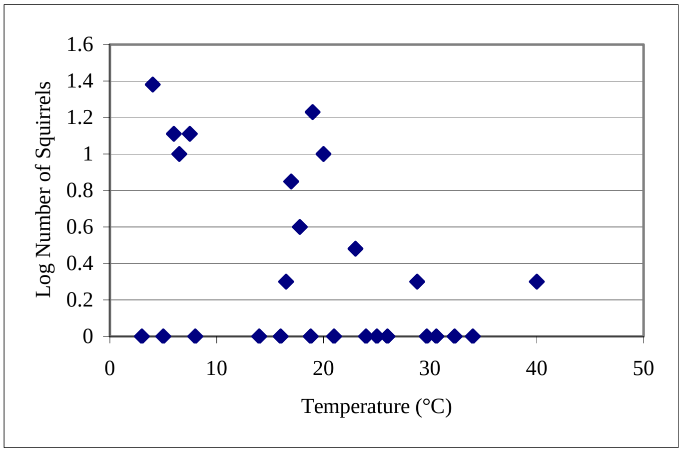

Figure 1. Significant negative relationship between log of number of squirrels observed and air temperature.

DISCUSSION

As we hypothesized, squirrel foraging activity was significantly correlated with temperature (Fig. 1). Our data suggest that there is an increase in squirrel foraging with decreased temperature, in the range observed. However, if squirrel foraging activity were observed at even lower temperatures, such as in winter, there may have been a difference in activity that would not have followed the observed trend. Furthermore the observed correlation between squirrel foraging and temperature does not take into consideration time of day. As shown in Table 1, time of day is a significant factor in the number of squirrels foraging and may have confounded our analysis of the effect of temperature on foraging activity. Our data suggest that maximum foraging occurs in the morning, consistent with the findings of Halloran (1999). However, there seems to be a decrease in activity in the evenings. Our data also suggest that squirrels forage most in low to moderate temperatures and avoid higher temperatures. This is consistent with the finding that squirrel foraging activity is decreased in the afternoon when temperatures are highest.

Our individual observations of foraging activity may not have been independent because squirrels were not identifiable, so large numbers of squirrels observed may be due to one squirrel returning to the food source. It has been found that squirrels are capable of relocating buried food after days to months (Macdonald 1997). Periodically changing the location of the feeding area is recommended to increase data independence.

Temperatures recorded may have been somewhat inaccurate because location of the thermometer caused it to be in the sun or shade at different times of the day. To ensure accurate temperature readings the thermometer should be placed in an area that is always in the shade or the sun.

Another factor that could have affected squirrel foraging was the presence of humans. Since the study site was not completely remote there was some human interference. Sometimes during our observation periods a human with a dog would walk through the field or the grass in the field was being mowed. More data are necessary to determine whether temperature affects foraging activity. It would be beneficial to conduct observations throughout the year in order to increase temperature range. A study site far removed from human activity may eliminate human effects. A larger study site (more habitat) would be necessary to observe more squirrels.

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