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Article

Spider Density Shows Weak Relationship with Vegetation Density

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SUMMARY

Evidence supports that spiders have many ecological benefits including insect control and predation in the food chain. Percent of vegetation coverage and spider density may be correlated; our study compared 18 different locations with different percent coverage of vegetation using a sectioned quadrat and the field method known as beating vegetation. In locations with high vegetation, 76–100% covered area, we found an average of 0.599 spiders per quadrat with a standard deviation (S.D.) of 0.465. In intermediate vegetation, 25–75% covered area, we found an average of 0.44 spiders per quadrat with an SD of 0.07. In low vegetation, 0–24% covered area, we found an average of 0.05 spiders per quadrat with an SD of 0.288. While this data supported the initial hypothesis concerning a correlation between percent coverage of vegetation and spider density, a limited sample size and statistical review failed to reject the null hypothesis that there is no direct correlation between the percent coverage of vegetation and the density of arachnids.

INTRODUCTION

In the fall of 2018, a group of students completed an unrelated classroom study to determine the density of terrestrial invertebrates in a surveyed area on the campus of a rural south-central Pennsylvania school. The results of the study unintentionally yielded 14 arachnids. The discoveries of that exploration led to the focus of this investigation: assessing spider density in areas with high and low percent coverage of vegetation. Without spiders, there would be an overwhelming number of harmful pests because spiders are among the most abundant invertebrate predators (1). If there are less harmful pests in ecosystems due to spider density, there are ecological benefits for humans as well as animals. Numerous factors such as insecticides and predators influence spider density. The surveyed area was located within an agricultural-based community. The use of insecticides on crops in the surrounding area affects arachnid density because they are sprayed to protect plants from predatory insects. Herbivory selection may also influence spider density as noted by the Pennsylvania Game Commission. The density of vegetation may also be affected by the presence of predators (2). The premise of this study was investigating a correlation between the percent coverage of vegetation and the number of spiders found at various locations. To accomplish this task, the following research question was posed: how does the abundance of vegetation correlate with the number of spiders in different habitats? Research locations were in Adams County at a suburban high school and elementary school. This study set out to test the hypothesis that there are more spiders in areas with higher vegetation coverage. The results yielded a higher spider count in locations with vegetation coverages over 75%, though the differences observed were not statistically significant. The standard deviation from the high vegetation was 0.599 + 0.465 for the category. Whereas standard deviations from the low vegetation sites was 0.32 + 0.288. Other comparisons include temperature and spider density. These results all showed insignificant values and the results were inconclusive with the original hypothesis.

RESULTS

There were six locations of low percent (0–25%) vegetation coverage and two locations with intermediate percent (26–75%) coverage **(Table 1)**. There were also ten locations with high percent (76–100%) coverage **(Figure 1).** All locations reside within South-Central Pennsylvania **(Figure 2)**. There was an average of three species of plants in each location. Data was collected in April and May of 2019, as well as October and November of 2019 **(Figure 3).** In addition to testing our hypothesis, we did a preliminary investigation on whether the temperature and time of year were a factor in spider density in order to learn more about spider habitats in Pennsylvania. While these factors would not influence vegetation coverage, they were viewed to alter the spider density.

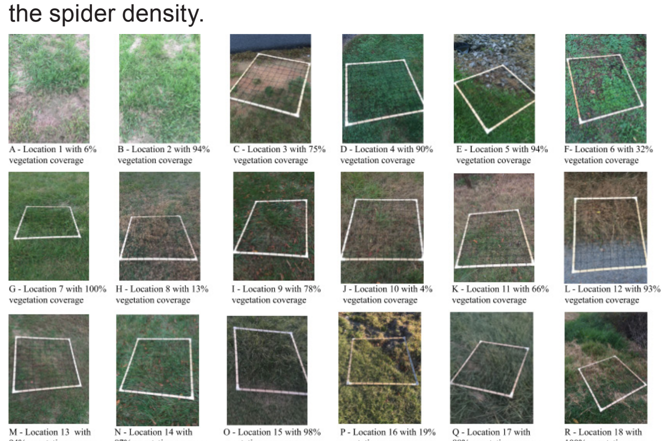

Figure 1: The 18 tested locations and their vegetation percent coverage. The percent coverage was determined by viewing the vegetation that poked through the top of the string. The observed dead vegetation was likewise included in these values. The percent coverage was determined on the first day of data collection.

Each location and each day of collection yielded a varying number of spiders. A minimum of 0 spiders was found at any location, and a maximum of 7 spiders, as well as a maximum SD of 3.73 on the most abundant days. Locations 1, 5, and 6 were the most consistent throughout the collection days **(Figure 3)**. When we plot the mean number of spiders collected per location along with the spread of spider collection data, we saw that the variance was very large, indicating the possibility of the uncontrolled factors such as grass being mowed and temperature affecting spider density **(Figure 4).**

Location ID	Percent Coverage	Description
1	6	Adjacent to a creek
2	96	Adjacent to a creek
3	75	Open grass field
4	90	Open grass field
5	32	Open grass field
6	89	Open grass field
7	100	Forested area
8	13	Walking path at a local park
9	78	Field with varying vegetation
10	4	Field with varying vegetation
11	66	Walking path at a local park
12	93	Field with varying vegetation
13	11	Walking path at a local park
14	87	Field with varying vegetation
15	98	Field with varying vegetation
16	19	Walking path at a local park
17	88	Forested area
18	100	Field with varying vegetation

Table 1: The location descriptions and the percent coverage of each surveyed location.

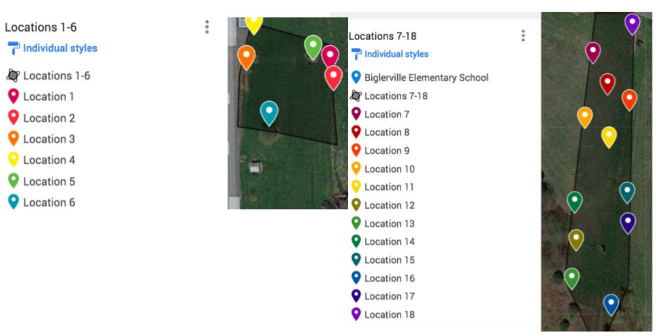

Figure 2: Locations of the 18 sites. Locations 1-6 are at the high school and Locations 7-18 are at the elementary school. Both are in Adams County in a suburban area.

This research sought to investigate a correlation between the percent coverage of vegetation, the independent variable, and the density of spiders. Calculating for spider density, the dependent variable, in areas with high vegetation (76–100%) coverage, the data was more spread out on the box and whisker plot for the average spiders collected in the category **(Figure 5).** The aggregated data for intermediate (26–75%) vegetation was not very spread out due to the limited sample size, therefore that comparison was removed **(Figure 5).** The p-value for a paired t-test comparing high and low percent vegetation coverage categories was 0.072. Therefore, we cannot reject a null hypothesis that spider density is equal across high and low vegetation densities.

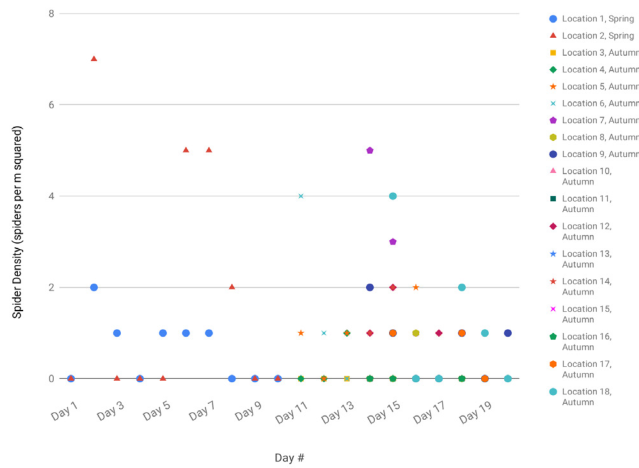

Figure 3: Spider density by day in each location. Spider density was calculated as the number of spiders found in the quadrat, divided by the area of the quadrat.

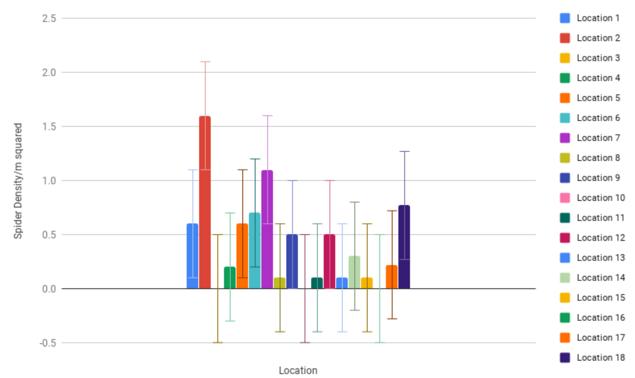

Figure 4: Spider density per location. Bars show the mean spider density and the error bars to show the standard error of spider density calculated from spider density.

We found that 41% of the variation in the average number of spiders was explained by variation in vegetation coverage **(Figure 6)**. We found a correlation coefficient (r) of 0.41. Using the correlation coefficient, we calculated the variation (0.41) in an average number of spiders found that was explained by the vegetation coverage. The p-value result is 0.343. The data substantiates the null hypothesis that there was no correlation between spider density and vegetation coverage since statistical measures did not support the focal hypothesis.

With this study, the daily atmospheric temperature seemed to influence the presence and collection of spiders. The possible correlation between spider density and temperature was represented by determining the average daily temperature in Celsius graphed with the mean daily spider density for all locations. The temperature was 15°C when there were more spiders collected on average. Conversely, when the temperature was lower than 15°C, fewer spiders were collected **(Figure 7).** While this result was not part of the original hypothesis, this initiates future investigations.

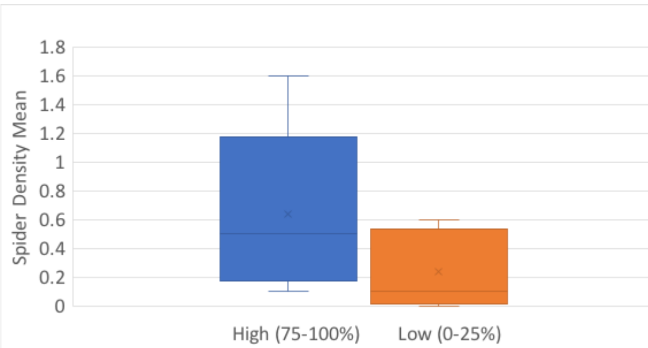

Figure 5: Distribution of the mean spider densities in low, medium, and high vegetation quadrats. Mean spider density per site was calculated by averaging the spider density across all of the collection days (n=18).

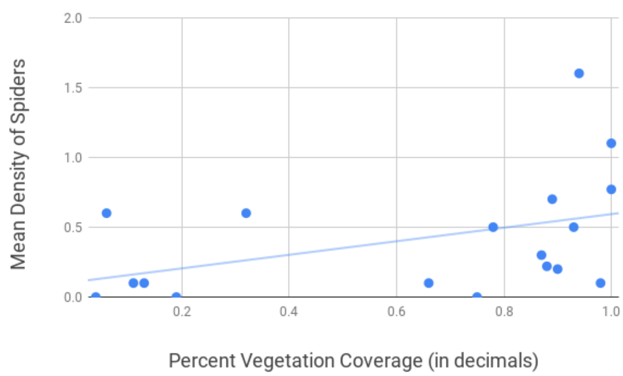

Figure 6: Scatterplot of the mean number of spiders vs. vegetation coverage of each site. The trendline represents the line of best fit to the data (0.41).

DISCUSSION

A recent study found that spiders thrive best in locations where there is a lack of vegetation. There is no evident correlation between spider density and the percent coverage of vegetation. Our data showed a weak correlation between vegetation coverage and spider density, though a low sample size and lack of mid-range vegetation coverage sampled may have deterred a more substantial correlation. Another possible factor for this weak correlation could be that data collected from Location 1 and Location 2 was in April, whereas the collection of data from Locations 3 through 18 was in October and November. If the first ten days of data collection were negated from the final results, we calculate a correlation coefficient of 0.51, potentially indicating a stronger correlation between the associated variables as shown with the *p*-value of 0.05. By removing the first ten days of data collection, because of the seasonal differences, the correlation is stronger; the first ten days were not removed to maintain ethical scientific practice. In plotting the data, there was a lot of variation among our sampling sites in spider density, even among the sites with similar percent coverages of vegetation. Therefore, the null hypothesis supports no direct correlation between spider density and percent coverage of vegetation.

Given that there was a variance in time of collection, time of day, and seasonal variation, the correlation between spider density and vegetation coverage could yield different results. The data from Locations 1 and 2 were collected in April and May, whereas the data from the remaining locations were collected in October and November **(Figure 3).** The data from Locations 1, through 6 were also collected from 10 A.M.-11A.M., and the data from Locations 7 through 18 were collected from 4 P.M.-6 P.M. The time of day could affect the results because there are different species of arachnids active during different hours of the day (2). The possible error in not sampling our locations for spiders multiple times a day could have altered the results as the time of collection each day could change the spider density. The grass was also mowed multiple times throughout the duration of the study, which could have varied the results because the percent coverage was different in different stages of the study. One can infer that during the spring and summer months when vegetation is denser and taller in the northeastern section of the United States, spider presence is more visible. Consequently, cooler seasons in the northeast, autumn and winter, will most likely show a decrease in the abundance of Arachnida in areas with similar flora characteristics. We saw that as the temperature warmed, the density of spiders increased, which can correlate with the life cycle of spiders. However, the possibility of factors influencing the density, other than vegetation coverage, was beyond the scope of the study **(Figure 7).**
Future work in studying spider abundance should sample

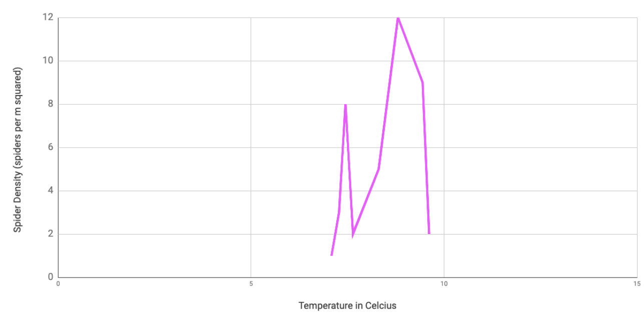

Figure 7: Temperature denotes the average daily temperature, according to NOAA, and the spider density is the mean spider density across all locations per day.

more sites with varying amounts of vegetation and track how spider abundance at these sites changes with the daily temperature and season. Possible new questions to ask would include whether spider abundance changes with availability of prey and other insects, the time of collection, and proximity to urban development. This study would inform one of the possible variables in spider density studies and how vegetation appears to show no significance in the density values.

MATERIALS AND METHODS

Four-meter sticks attached together created a square and then sectioned every ten centimeters apart using string. This process was repeated until there were one hundred small squares, each square representing one percent of the quadrat. The study locations were randomly selected by spinning around and throwing the sectioned quadrat in the air and using its landing as a location selection. This was done randomly after observing the vegetation quantities. A meter stick was used to beat vegetation and a plastic plate was used to collect spiders that fell. Spider density per day was calculated as the number of spiders collected on the plate, divided by the area of the quadrat. Mean spider density per site was calculated by averaging the spider density across all of the collection days.

Data was collected from Location 1 and Location 2 in April and May of 2019 and the data from the remaining locations were collected in October and November of 2019. Percent increase in spider density was determined by dividing the sample size by the total surveyed population. When determining the percent vegetation, live or dead vegetation seen through the string of the sectioned quadrat was quantified. Data was collected three times daily across 18 different school days. A scatter plot with a linear regression and error-bar graph was used to display the results.

We used Google Sheets for statistical analysis. We performed a *t*-test to compare the spider abundance across low, intermediate, and high vegetation areas. A correlation coefficient was calculated to examine the strength of the linear relationship. An R-squared value from that correlation coefficient was used to understand the percentage of variation in spider abundance explained by the variance in vegetation coverage **(Figure 6).** To calculate the statistical significance of our correlation coefficient, we first calculated the *t*-value of cour correlation coefficient using the following formula.

We calculated in Google Sheets (5) the critical *t*-value

$$t = \frac{r * \sqrt{n-2}}{\sqrt{1-r^2}}$$

for a *p*-value of 0.05 using the T.INV.2T(p, df) function, with a probability (p) = 0.05 and degrees of freedom (df) = 18-2=16. We then determined if our *t*-value was greater than the critical *t*-value; if it was, then our correlation coefficient was significant. We calculated a *p*-value for our correlation coefficient using T.DIST.2T(t, df), where "*t*" represents the *t*-value from the observed data, and df = 16.

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