The Abundance and Biodiversity of Insects Along the New River.

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Introduction:

Biotic and abiotic relationships, such as the relationship between water, plants and insects, have a large impact on the environment. Insects are very abundant organisms in almost any ecosystem. They serve a variety of ecological functions including, but not limited to: helping plants reproduce, acting as a food source for many organisms, and serving as a mechanism for disease transfer (Häuser and Riede, 2015). Additionally, these organisms can indicate changes in the soil or plant health that an ecosystem might be experiencing. Both abiotic and biotic factors can change an insect's physical, physiological, and behavioral patterns (Khaliq, Javed, Sohail, et. al, 1996). In a riparian system, numerous amounts of insects switch from water to land constantly. In a water source such as a lake, there is a much larger amount of movement than in a smaller source like a stream (Gratton and Zanden, 2009). It has been shown that there is a decrease in insect abundance as the distance increases from the water source (Jackson and Resh, 1989). However, there is still a significant impact, such as the health of the land, predation and competition, and degradation of local plants, that these insect populations have on the terrestrial landscape (Khaliq, Javed, Sohail, et. al, 1996). The plant community surrounding the water source at the New River is diverse. Seeing the diverse plants that make their home in Giles County, Virginia, leads to the observation that there is a large amount of biodiversity in terrestrial insects. The amount of vegetation positively correlates with the abundance of insects. The diversity of terrestrial insects will vary due to the components of the land, meaning the soil and the species of plants. However, there is still substantial insect diversity and abundance where higher levels of plant vegetation is found (Tabor et al. 2005).

The specific interactions between an organism and its environment of insects near a water source is an area of ecology rarely studied (Bootsma, 1998). The density of insects along individual transects near the shoreline show variations of species richness as the distance increases or decreases from the water source. Where there is plant diversity, there will also be insect diversity (Murdoch et al. 1972). At the site chosen for this study, there is more plant diversity as you go further inland. Inland dispersal patterns of aquatic insects were studied using traps in Detroit and determined that the greatest densities of insects can be found at either some point inland or right on the waters edge (Kovats et al., 1996). Insect location is heavily species-dependent (Kovats et al., 1996). Competition between insects along a transect of space near a shoreline can alter the density of the population. Insects can have different trophic features that allow them to be consumers or prey, altering where different species of insects accept their nutrients (Wesner, 2010). As a result, it has been found that an increase in species density has proven to elevate prey availability (Wesner, 2010). The study of the relationship between insects, their trophic abilities, and their location to the shoreline will open up opportunities for further research into the constantly changing habitat of insects (Cummins, 1973). The general ecological importance will be studied rather than the individual trophic patterns of specific insects due to the need for common, or generalized, information about insects in this environment.

The New River is home to many abiotic and biotic relationships, including the relationship between insects, plants, and water. The abiotic factors, such as temperature and rainfall alter the relationship terrestrial arthropods have with their habitat. For example, if the temperature is fluctuating to extremely cold and extremely hot temperatures, the insects could potentially seek shelter using the surrounding plant community. Also, if the insect is faced with heavy rainfall that could potentially cause the tide of the river to shift, the insects may migrate towards drier land, away from the potentially harmful water. The width of the river bank allows for ecological movement of the insects towards and away from the river. The density of insects along the width of the bank is addressed in this study as we collect and count the number of insects along a transect. The number of insects found at each transect correlates to the biodiversity of the area. This study poses questions aimed at biodiversity. Biodiversity is defined as the species richness and equitability, also known as the total number of individuals in a species or the total biomass for a species (Alkorta et al., 2003). The New River allows us to assess biodiversity using insects and their location at each transect. By conducting research near a water source using the biotic factors found within the surrounding soil, the soil's pH, toxicity, and overall health can be examined when using the species richness and diversity. (Kobuszewski and Perry, 1993).

This three-week long study will address the questions regarding the movement and density of insects near a water source, and potential impact of insect density on the environment surrounding the area. The questions include: (I) Is there a change in insect abundance as ecological movement occurs near a water source? (II) Is there a change in species diversity in areas further from the water source? In this study, we tested the hypothesis that as the distance from shore increases, higher plant diversity and density will provide terrestrial arthropods with an improved and well fit habitat.

Materials and Methods:

Study Site

The study was conducted along the bank of the New River in southwest Virginia. This site was chosen due to. Additionally, it is a free and public space that was readily accessible. The study was conducted along the bank of the New River in southwest Virginia. This site was chosen due to its wide and dense river banks. Additionally, it is a free and public space that was readily accessible. Along the transect going from 0 to 20 meters, the foliage changed as a result of the distance from the water. For example, foliage and organisms near the water source were able to grow and thrive in a soil with sand as a main component. As the distance increased, the ratio of soil to sand visibly decreased and the soil was able to grow a larger variety of species, which have the potential to be home to more diverse species. Due to this larger variety, the New River is home to many abiotic and biotic relationships. This site was chosen because of the many abiotic and biotic factors, including insects, plants, water, and soil. Some species of plants common to southwest Virginia include the *Acer negundo*, *Adiantum pedatum*, and *Alnus serrulata* ("Southwest Virginia Flora - Species list" n.d.). Some insect families commonly found are Formicidae, Chironomidae, and Rhopalidae ("Virginia Insects (802 Found)" n.d.). Lastly, the average rainfall of Giles County, the area in which the New River resides, is 39 inches per year ("NOAA - National Weather Service - Water - County" n.d.). Using this statistic, it can be concluded that Giles County does have a period of time where rainfall is a significant abiotic factor in the insects environment.

Study design

Five transects were established, each set 60 meters apart from the previous one. Five pitfall traps were established at each individual transect, for a total of 25 traps. The traps were placed at 0, 5, 10, 15, and 20 meters from the edge of the water. Due to changing water levels, the "0 meter" traps were placed directly behind the first green patch of grass, which was around 2 meters from the water for each "0 meter" trap set. This ensured that the traps were not hindered by a change in water height. Each trap consisted of a 16-ounce deli cup lined with cheesecloth and secured with a rubber band around the edges. After the cheesecloth was in place, each deli cup was filled to approximately 2.5 centimeters about a fourth of the way up with water mixed with a tablespoon of dish soap. The soap was added to help trap the insects that enter the cup. Each trap was placed into the ground to where the lip of the cup was level to the ground. To protect the trap from the rain, a styrofoam plate was placed over each trap. The plate was elevated over the the trap about 2 inches by sticking three skewers into the plate. The three skewers were then secured into the dirt surrounding the cups (Fig. 1). This study was conducted over a three week time period, during which traps were checked weekly. At the time of collection, the old traps were secured in bags, and new traps were set up for the upcoming week of collection. The samples were then taken back to the classroom, and the insects were put into a 70% ethanol solution to preserve the insects until they could be identified. Only insects will be analyzed in the data. Other common organisms such as arachnids and crustaceans will not be looked at when comparing biodiversity.

This study was performed using observational approach. We wanted to observe any change in species diversity as a water source got further from the trap and that was best done using observational techniques.

Fig. 1. Pictured are examples of the pitfall traps set out along the 5 transects on the banks of the New River. (Author Image, 2019)

Data Collection

After preservation took place, the insects were individually removed from the collection tubes and examined using tweezers and a white plate to show contrast. Insects were identified to family name by using National Audubon Society Field Guide to Insects and Spiders. During examination, five of the families were not insects, which included crustaceans, worms, slugs, and two unknown families. These five categories were not included in the interpretation of the results due to the questions that were posed. After the removal of non-insect families, there were 12 families of insects that we found and ran significance tests on. We used the Simpson's index to describe the diversity of insect communities.

Data Analysis:

To test the relationship between insect abundance and distance from the river, we used a generalized linear mixed model using the Poisson distribution. The transect was a random effect, the distance from water was a fixed effect, and diversity was the response variable. For hypothesis testing, we used a likelihood ratio test comparing this model to a simplified version that included transect only as a random effect. To test the relationship between insect diversity and distance from the river, we used the same model structure and approach, but with diversity as the response variable and a normal distribution.

Results:

The level of species diversity and abundance of insects did not show any change as distance increased from the river. The result of the linear mixed model using diversity as a response, distance as a predictor, and transect as a random variable was not significant ($\chi^2 = 1.30$, $P = 0.25$; Fig. 1).

The result of the generalized linear mixed model using total herbivore abundance as a response, distance as a fixed effect, and transect as a random effect and Poisson as the distribution was also not significant ($\square^2$ = 1.26, *P* = 0.26; Fig. 2).

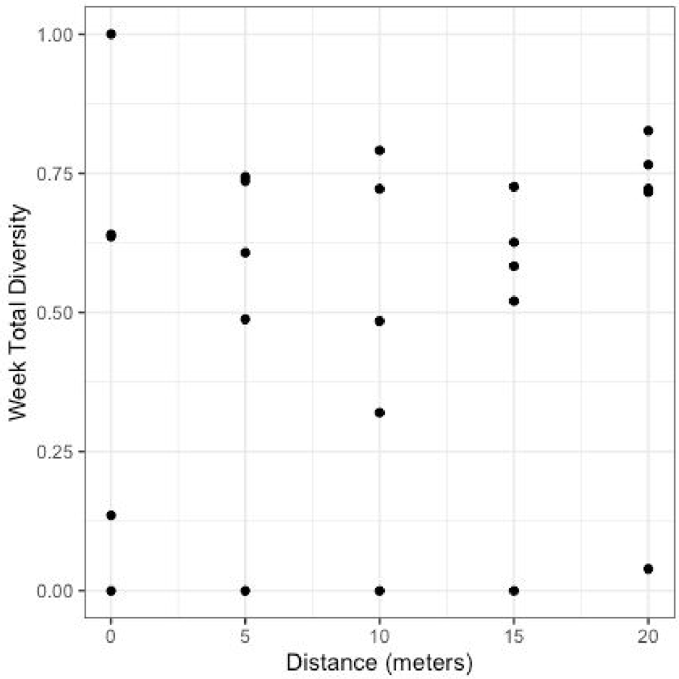
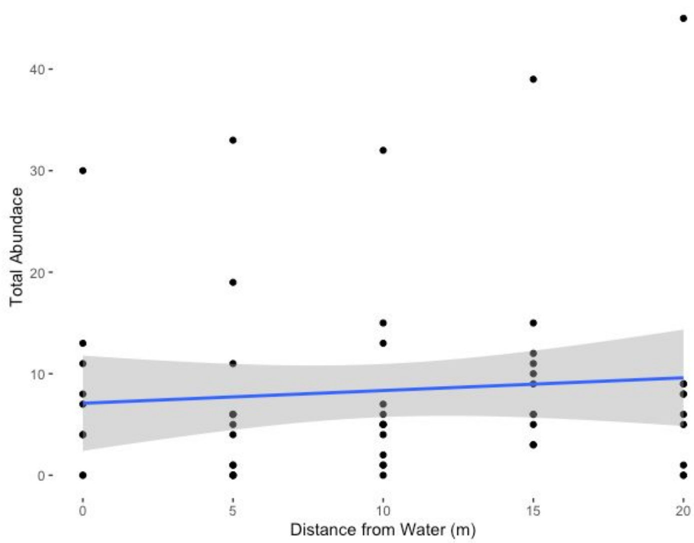


Figure 1: The total diversity of insects each week versus the distance in meters from the water at the transects at the New River using the Simpson's index.



Graph 2: The total abundance at each distance for each week.

Discussion:

Our hypothesis for this experiment was that that as the distance from shore increases, higher plant diversity and density will provide terrestrial arthropods with an improved and well fit habitat. After the analysis of the data, there is no significant relationship between distance from water and abundance or diversity. Thus, the data showed no pattern that could support or reject the hypothesis. Our experiment was not supported by other works of literature. In other experiments it was shown that plant diversity and insect diversity have a direct correlation (Novotny, 2006).

The differences in our data compared to other experiments could be due to temperature, the changing weather, human interference and other abiotic factors. During our experimental period we faced a significant change in temperature from week to week. There may have been lower levels of movement and activity to the very low temperatures. Additionally, during this time period there were several storms. We believe the height of the water level must have increased and either removed or flooded 40% of our “zero” meter pitfall traps. The rain could have also interfered with the natural movement of the insects. There was also some human interference that may have impacted our data. 2-5 cups were found to be removed or destroyed every week. The weather and human interference lead to about 24% of our traps to be lost. Furthermore, distance to water may not be the correct factor to determine ecological movement. There may be some abiotic factors that need to be explored.

The caveats in this experiment present a new series of questions can be posed about the patterns of insects near a water source. These questions include: I) Would the patterns be different if the experiment just analyzed insects of flight? II) Does the time of year affect the movement? III) Does the abiotic elements of soil affect abundance as the distance from water increased?

In conclusion, this experiment emphasizes the lack of knowledge about the insect movement patterns. Our data was unable to support or reject our hypothesis, thus, we were not able to connect the aspects between distance of water and biodiversity or abundance. Further studies should be conducted to determine the reason for insect movements. Possible answers include differences in abiotic factors. Factors like nitrogen, phosphorus, and pH concentrations should be analyzed. Adding more transects would help eliminate bias as well. Additionally, picking a location that was less traversed by humans would help eliminate human interactions. Answering the questions about the interactions that insects have will help us further understand patterns in other organisms.

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