The Density and Diversity of grasshopper Communities in Western Maryland

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Abstract

The purpose of our study was to find the density and diversity of grasshoppers in Western Maryland to see the effect of patch size on the grasshopper community. Grasshoppers were chosen as our study subjects because they have a short life span and they reproduce rapidly so the team would not be disturbing the environment that much. The researchers tested eight different sites, four small and four large. The Poisson binomial sampling method was used to find the density. The team tested for the percentage of different types of vegetation in the sites. The diversity was found by using the Shannon Weaver-Weiner Index.

It was found that there is a significant difference in grasshopper diversity between large and small patches ($p<0.05$), but there was not any significant difference between grasshopper densities in the patches. The density was not affected by the size of the patch or by the types of vegetation. A significant correlation between the grasshopper diversity and the percent bare ground was discovered ($r=0.619$); all other types of vegetation percent cover had no significant correlation with the diversity. The team discovery is important because it might mean that some species of grasshoppers need bare ground for heat or another reason.

Introduction

Grasshoppers are an important part of the ecology in Western Maryland. Humans affect the environment of grasshoppers by fragmenting their habitat. Fragmentation is when disturbances convert large areas of natural habitat to smaller patches, which may differ or may be isolated from the original habitat. Roads, mining, development, agriculture, natural disasters, floods, fires, are examples of disturbances. The negative effects of fragmentation are greater in a landscape that consists of native vegetation surrounded by agriculture and more developed land (Saunders et al., 1991). Fragmentation causes reduced migration, a change in microclimate, changes species composition, and crowding.

Grasshoppers compete with people in agricultural fields and are considered pests. Since grasshoppers rapidly reproduce and produce many offspring, the population size of grasshoppers can become very large. If the grasshopper population size is too high, consequences such as outbreaks or a disruption in the food chain may occur. Outbreaks are caused by overpopulation in the grasshopper community. If overpopulation occurs, then severe economic damage can occur. Swarms of grasshoppers may devastate the crops on farms. If the grasshopper population is too low, a disruption in the food chain may occur. In addition, if a sudden over-abundance of grasshoppers occurs, there may not be enough food for them. Enough food for a small amount of time will be available, and then all of a sudden there will be a crash in the grasshopper community. If there are few grasshoppers in an area then the predators that relied on them must either find another food source, relocate, or die. The grasshoppers rely on a lot of vegetation. An example if there were ten adult grasshoppers every yard square, they would destroy the whole field (Pfadt, 2000).

The team came up with four hypotheses for this study. The first hypothesis states diversity of grasshoppers in the small and large patches would be different. The second hypothesis is that there would be a difference in the density of grasshoppers in different sized habitats. The third hypothesis is there is a relationship between vegetation varieties and grasshoppers' density. Finally, the fourth hypothesis is that there is a relationship between vegetation varieties and grasshoppers' diversity.

A study was conducted in Montana, in a region similar to western Maryland. The researchers determined which rangeland in that area has the greatest density of grasshoppers. They found that the density of grasshoppers differs in habitats with different temperatures and elevation (Kemp et al, 1990). As a result of this experiment, density may be predicted at each site in Western Maryland if temperature and elevation are known.

A group of students working at Frostburg State University have been studying the density and diversity of grasshoppers in different large and small habitats in Western Maryland. By studying the density and diversity of grasshoppers in Western Maryland in different size patches, we can predict the effects of fragmentation on the ecosystem. If patches of different sizes of land are used as a model of fragmentation, then the results of this study can be related to what might happen in larger spaces where more fragmentation might occur. The information from the results may be able to be used to save endangered animals that might be killed from fragmentation. The habitat diversity plays a role with species diversity because if there are many different habitats there will be a higher diversity of species.

Many different species of grasshoppers live in Western Maryland. There are 600 grasshopper species nation-wide and many of those grasshoppers live in the Western United States (Kemp et al., 1990). There are many more grasshopper species living in the Western United States than in Western Maryland. The high quantity of grass is probably because in the Western United States there is a high amount of habitat diversity and greater available resources like fields, than in Western Maryland. The quality and quantity of vegetation at a patch may determine how many or what kind grasshoppers will be at that site.

Craig (1999) conducted a grasshopper density study on four different types of vegetation. This study revealed that different species of grasshoppers prefer different kinds of vegetation. Grasshoppers are being studied here because they are in great abundance, they are easy to catch, the vegetation directly affects them, and an entire population may be found in one patch. Grasshoppers also have rapid reproduction, which means that when they are caught and taken out of their habitat, the population may not be affected much.

A patch is a community that is surrounded by environment with different community set up (Saunders et al, 1990). A patch is usually created by a disturbance. Grasshoppers usually live in grassy patches and fields Grasshoppers reproduce rapidly, have a short life span, and are highly diverse. Grasshoppers are members of the insect class, and are in the order Orthoptera. The study restricted the data to information on the family of grasshoppers called Acrididae (short-horned). Some subfamilies of grasshoppers in Acrididae are: Acridinae (slant-faced), Gomphocerinae (slant-faced), Melanoplinae (spur-throated), and Odipodinae (banded-wing).

Grasshoppers are generally herbivores, or plant-eaters, and compete with livestock, humans or wildlife for food, especially when their population sizes reach pest proportions. They lay their eggs underground for winter and some are migratory. Grasshoppers are sensitive to dampness, altitude, flora, and they communicate through wing displays and sounds. If migration to other habitats declines then the community size will increase and overcrowding in some areas will occur. Also if a change in species composition occurs then some populations may have increasing competition and will start to decrease in population size. Competition between grasshoppers and other animals can cause grasshopper population size to decrease. The increasing birth rate affects the population by increasing the amount of individuals in the area. Immigration might increase the amount of grasshoppers because other grasshoppers are coming in to the patch.

Why focus on grasshoppers for this study? Grasshoppers are being studied because they are common and easy to catch. They also reproduce fast, and it will not affect the community much by collecting them. They are also good to study because they might be sensitive to the patch sizes.

METHODS

This study started on June 20, 2000 and ended on July 12, 2000. A team made up of 10 students from the Regional Math and Science Center set up 8 sites in Allegany and Garrett County in Maryland. They used eight patches instead of one of each because the more tests they did, they had less chance of statistical error.

The small test sites that were selected were the Frostburg State University Arboretum, Western Maryland Ornithological Society Bird Sanctuary small, Rita Hegeman's Backyard, Rita Hegeman's patch off the trail. The large chosen sites were the Western Maryland Ornithological Society Bird Sanctuary large, the Power Lines right of way at Swamp and Westernport, the Power Lines right of way at New Germany and the Moran Strip Mine.

The sites were chosen because they were easily accessed, and relatively undisturbed. They chose small patches because they are isolated with a totally different environment surrounding them. All sites had grassy vegetation but differed in the relative amount of vegetation types. They also had about the same amount of disturbances. Sites were mowed at least once a year. The largest small patch was about 9,000 meters squared and the smallest large site was about 40,000 meter squared. The students used the large patches to represent non-fragmented habitats, and the small patches to represent fragmented habitats.

They went to every site only twice. One day they set up the site and collected vegetation data between 9:30 am and 12:30 pm. Then the next day they collected density and diversity data, and that completed data collection for that site. The density data was collected the day after the vegetation data between 12:30 pm and 3:30 pm. The diversity data were collected after the density, the same day, between 12:30 pm and 3:30 pm. Data was collected on sunny days because that is when the grasshoppers are most active.

The team set up five transects that were 70 meters long. Each transect was 10 meters apart from the other. Rings of $0.1m^2$ and flags were placed every 10 meters down each transect. Due to the shape of the patch, some transects were made smaller or larger but there were still forty rings total per site and transects rows were still ten meters apart. The purpose of setting the flags was to locate the rings easily.

The team used $1m^2$ quads segmented into 25, $0.04m^2$ squares for vegetation analysis types. The vegetation data was collected by randomly picking two rings on each of the transects and using the quads to find the percent grass, rocks, forbs, tree and shrubs, litter, bare ground and other and recording the percent in the data book.

At least 24 hours after and if the weather was sunny and warm, density data was recorded. The team took density data by two people going along the transect line and sneaking up to the rings located on the line. They had to see if any grasshoppers jumped in or out of the ring, tapping the ring with the end of the pole, and also feeling through the grass inside of the ring. If grasshopper were not present in the ring, then a “0” was recorded. If there were one or more grasshoppers present in the ring, then a “1” was recorded. The team did that for all 8 rings. The method that was used is called the Poisson Binomial Sampling Method. This method was used because it is accurate and easy for the unskilled (Legg et al., 1993). For each site, the percentage of rings with grasshoppers present was found. That percentage number was then converted into grasshopper density per square meter using a table from Legg (1993). A 2 Sample T-Test on Minitab 11.0 and 12.0 were used to test the first hypothesis on density. The test determine if the average grasshopper density of small and large patches were different. The p level was set at 0.05%. To determine the relationship between each vegetation variable and grasshopper density they used correlation. The “r” value had to be 0.6 or greater.

After density data was recorded, diversity data was then taken. The team took diversity data by going along the transect doing 200 sweeps with a net and stopping every 10 sweeps checking the net to see if there are any grasshoppers caught. One hundred sweeps were done low in the grass to catch the nymphs and flightless adults, also 100 high in the grass to catch the adults. After about five or ten sweeps, see into the net to see if there were any grasshoppers. One person did the “attack”. That team member does 200 sweeps and stalks the grasshoppers to catch them. If there were grasshoppers caught its identity would try to be determined. If a grasshopper was caught that could not be identified could not identify, then they took those back to the lab to identify them. The team used the dichotomous key to identify the individual species in each site (Helfer, 1953). The dichotomous key has characteristics, which describes a certain species of grasshopper. When using the dichotomous key, the students looked at different grasshopper body parts. The group examined the three sections of the body, which are the head, thorax, and the abdomen. The group also looked at other parts of the body, like the legs, wings, cerci, pronotum, genitals, spine, etc. After all the sweeps the grasshoppers that were identified would be let go.

After all the grasshoppers were identified, the diversity of each site was found by using the Shannon Weaver Weiner Index which says $H' = -\sum (p_i \text{Log} p_i)$. The higher the H', the higher the diversity. The max diversity and evenness of each site was found. The equation to find the max diversity is max H = log(number of species at that site). To find the evenness, the equation is $J = H'/\text{max } H$. Following this test, a 2 Sample T-Test was taken to test the second hypothesis to find out if the average diversity of small and large patches was different. To test the fourth hypothesis, a correlation test (Pearson) was taken to see if a relationship existed between vegetation percent cover variables and grasshopper diversity. Since there was a significant relationship between one vegetation data type and diversity, then a regression test was then taken to find out how the 2 variables were linearly related.

RESULTS

There was no significant difference in grasshopper community density in large and small patches. There was a significant difference in grasshopper community diversity in large and small patches ($p<0.05$). No correlation was seen between the grasshoppers' density and any type of vegetation variables. There was significant relationship between the percent bare ground and diversity (r=. 6197). The regression of grasshopper diversity and bare ground is shown in Figure 1. Rita Hegeman's patch off of the trail had the highest species richness of 7, and the Power Lines at Swamp and Westernport had the lowest richness of 4.

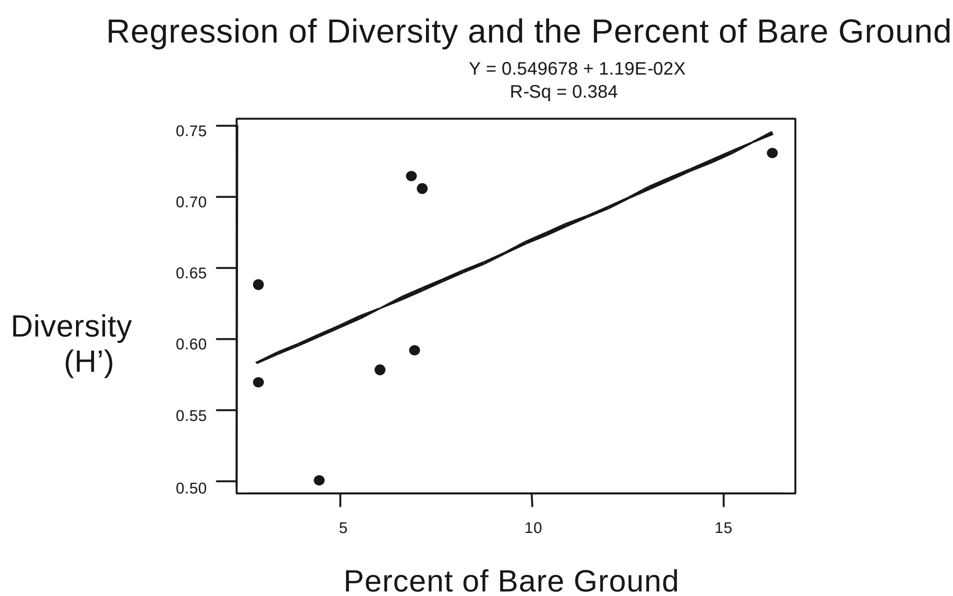

Fig.1. - This figure shows the Regression of Diversity and the Bare Ground. As the percent bare ground increases so does the diversity of the grasshoppers.

DISCUSSION AND CONCLUSION

The first hypothesis, which stated that the grasshopper density of small and large patches is different, was rejected. The second hypothesis, that stated, the grasshopper diversity of small and large patches is different, was accepted. The third hypothesis, which stated that there is a relationship between vegetation cover variables and grasshopper density, was rejected. And lastly for the fourth hypothesis, which stated that there is a relationship between vegetation cover variables and grasshopper diversity, was accepted for bare ground and rejected for all other variables. On Figure 1, the y-axis is the diversity or the H' and the x-axis is the percent of bare ground. Each dot represents a site. Figure 1 shows that there is a relationship between the percent bare ground and the diversity of grasshoppers. It shows that the graph has a positive increase. So as the percent bare ground increases, so does the diversity of the grasshoppers.

The diversity of the patches only depended on one of the variables that was used, and that was the percent of bare ground. The density did not rely on the vegetation cover. The students knew that the grasshoppers were active during warm periods of the day. Because grasshoppers are cold blooded they rely on the sun's heat, and bare ground warms quickly. The team's results are very significant to farmers and people who eat the farmers' crops. Most grasshoppers act as pests and can eat most of farmers' crops. By looking for how much bare ground is around, farmers may find out how many different grasshopper species are on their farm. With the information the team found farmers can exterminate grasshoppers before they are a problem.

Different species of grasshoppers need different habitat areas. Grasshoppers need a certain amount of space or certain kinds of food. In the sites, different types of vegetation were present, and different grasshopper species like different kinds of vegetation. When different vegetation is present, there may be a species of grasshopper that will prefer that type of vegetation. The data that was collected did vary from site to site because there were different species of grasshoppers in each site. When the vegetation data was taken, the team only looked at the types and not the species or actual lengths. At some of the sites the grass was high enough that the students could not see their flags along the transects.

The data could have been affected by the amount of disturbance in the sites or the amount of disturbance the researchers made. For instance, if the researchers were loud or walked all over the transects before the tests, it would scare away some of the grasshoppers. In the power lines, there was a sound omitted from them and this might cause the grasshopper to not be able to communicate with each other due to their location.

Grasshoppers could be randomly placed or clumped in a site. When the data was collected, the small site was completely covered by the transects but only a small part of the large site were covered by the transects. So if the grasshoppers were clumped in an area where the transects were and nowhere else, the grasshoppers' diversity would seem to be higher.

Another reason why the smaller sites may have a different diversity than the large sites is because the smaller sites would have less area for the grasshoppers to live. This would cause it be easier to catch the grasshoppers. While the larger site give the grasshoppers more area to live which would make catching the grasshopper more difficult. The data could have been affected if the site that was tested had the greatest or less amount of grasshoppers in Western Maryland. Since some transects in the small sites extended into the woods, some grasshoppers that live near the woods could have been collected and they would not have been collected in the large patches because the transect didn't go close to woods. Another reason is that the small sites could be too large be considered small sites.

The last reason why the smaller site may have had a different diversity than the larger sites is because of the grasshopper life cycle. For an example, *Melanopus bivittatus'* life cycle could have been in the stage where all of the adults have laid their egg and were dying. Then sites containing adult *Melanopus bivittatus* would have a higher diversity than the other sites, as the group did not expect.

Although the density was the same in both large and small patches this may not be a typical result of a change in patch size due to fragmentation. If an endangered animal needs to be saved, the quality of vegetation would be more important than the size of the land the endangered animal going in which it is going to live, since a species needs food to survive more than they need space to live in. One reason the density of the small and large is not changed due to fragmentation because the sites that were studied were only models and the sites were not truly fragmented. Assuming the sites were fragmented, and then the competition in the small patch would be high, therefore making the population decrease along with the density.

Due to the small amount of time, the researchers could not learn the different stages of each of the grasshopper so nymphs were not identified to species. Another type of grasshoppers that was not identified to species was the Long horn grasshopper. The Long horn grasshoppers were not collected because they were hard to handle and they would bite. If the counting of long horned and nymph species had been included then the data would have been more accurate, because all the species of grasshoppers would have been recorded.

The team did not test many sites; so there is a large room for error. The team could have visited more sites so the level of error could have been lowered. If more sites were added the results of the study would be more accurate because there would be a greater variety of data.

Some people on the team did not want to touch grasshoppers because they did not like bugs. The team did not catch some of the grasshoppers because they were too fast for some members on the team. At times the students wouldn't put the rings all the way on the ground, that would cause them not to be able to count the number of grasshoppers jumping out of the rings correctly.

It would be important to know the density of grasshoppers in taller grasses verses the diversity of grasshoppers in other types of vegetation. Could a group of researchers predict the density and the diversity of grasshoppers by the height of the grass at a site? Also, can a team of researchers predict the diversity of a grasshopper community just by knowing the percent of bare ground? The next question that was brought up from this experiment was could of the data have been different than the group expected due to the life cycle of the grasshoppers? A final question is will the diversity go down in the small patches if the bare ground will be filled with grass and other plants?

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