Habitat selection between grassland edges using two grasshopper species (*Chorthippus curtipennis* and *Pseudopomala brachyptera*)

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Abstract
Habitat selection of two grasshopper species was studied using a grassland edge to separate a 'wet' habitat that consisted of lush green vegetation and a 'dry' habitat that consisted of sparse prairie grasses. Several abiotic and biotic factors (length of grasshopper, soil moisture, vegetation species, and air temperature) were measured in order to identify the influence of grasshopper habitat selection. Both grasshopper species were collected on the National Bison Range in western Montana and placed in a pair of aluminum insect screen cages (0.01m^2 base and 0.90m height) that were joined at the base with a 15centimeter tube that served as a passageway that allowed grasshoppers access to both habitats. Three treatments were established within these cages 1) only *C. curtipennis* species 2) only *P. brachyptera* species 3) *C. curtipennis* and *P. brachyptera* together. This seven day study revealed that (on average) when alone and in the mix, *C. curtipennis* selected the wet habitat consistently. When alone and in the mix, *P. brachyptera* had no apparent preference of wet or dry habitat (df = 3 f = 12.412 p < 0.001).

Introduction

An edge can be defined as the junction of two different landscape elements (e.g. plant community type, successional stage or land use). This connection is either a well-defined boundary or a transition zone where plant and associated wildlife communities grade into one another (Yahner, 1988). In past studies, it has been documented that edge effects feature several complementary components that trigger different responses among species (Fagan et al. 1999). Three examples of species response to habitat edge is 1) the restriction or facilitation of habitat choice amongst species within a landscape 2) the facilitation of interaction between species that would otherwise not interact and 3) the contribution an edge can have on mortality of interacting species (Fagan et al. 1998).

Within studies of heterogeneous ecosystems, research has focused on abiotic edge effects linking them to specific population and community impacts. A common theme in recognizing the importance of habitat selection is the critical need to understand the processes through which species disperse and structure their communities. On a broader level, increased research on edge mediated effects may advance the understanding of species-area relationships (Fagan et al. 1999).

In previous studies, factors manipulated to study habitat selection that produced significant influence in habitat choice by grasshoppers included: availability of food or nutrients, vegetation structure, number of plant species, microclimate variables (such as temperature, humidity and light intensity), and soil characteristics (Joern 1982).

Grasshopper presence and species richness are positively correlated to the number and variation of plant species in different habitats (Squitier and Capinera 2002) For example, when grasshoppers choose a specific habitat, numerous species (such as the *Chorthippus curtipennis)* chose those with lush, tallgrasses that act as cover and serve as a valuable food resource. Others are known to choose dry sparse textures of vegetation in order to maintain their body temperature as a survival method (such as the *Pseudopomala brachyptera*).

Temperature as a factor has been shown to have both direct and indirect effect on grasshopper development and survival (Skinner and Child 2000) and it is likely that this could influence grasshopper population dynamics. Additionally, when tested in lab studies, several grasshopper species have shown significant responses in their reaction to both heat and light, where the effect of high temperature was usually more important than light (Joern 1982).

Soil characteristics are believed to important to grasshoppers through their effect on embryotic development and species survival (Skinner and Child 2000). Gardiner et al. reported that exposed soil can be beneficial to some grasshopper species by providing sites where they are able to bask because soil is much warmer than surrounding vegetation. Contrary, other grasshopper species require relatively moist grasslands and meadows with high soil moisture (Craig et al. 1999) to act as food resource and aid in predator protection.

The aim of this study is to determine whether or not there is a significant habitat choice within grasshopper species and if that choice varies between two selected species. In addition to this observation, I would like to know what factors influenced or facilitated grasshopper choice.

Grasshoppers are dominant grassland herbivores that are widely distributed in vegetation of the North American Great Plains including habitats containing eastern tallgrass, western shortgrass and northern mixed grass prairies (Craig et al. 1999). This study focused on habitat choice of *Chorthippus curtipennis* (Harris) and *Pseudopomala brachyptera* (Scudder). *C. curtipennis* (The Meadow grasshopper) is distributed among the western United States and Canada. It is most abundant in stands of tallgrasses that grow in hayfields, pastures, swales, roadsides, mountain meadows, and along the edges of marshes, lakes and ponds (Pfadt 1994). *C. curtipennis* feeds on mainly grasses and sedges but in the Midwest region, Kentucky bluegrass is the preferred host plant. *C. curtipennis* exhibits increased activity during high temperatures throughout the day. At rest, they can be seen close to the tops of grasses. As temperatures fall, they usually take cover under grasses in order to maintain body temperature (Pfadt 1994).

Little information is available on the species *P. brachyptera*. However according to the Slantface grasshopper of the Canadian prairies and Northern Great Plains guide, the species has increased in abundance and range during dry years. It has adapted well to the sidespread distribution of brome grass on prairie roadsides, where it is often found.

In this study, I predict *C. curtipennis* will prefer tallgrasses in the wet textured grasslands because in other studies (Craig et al. 1999) it has shown distinct habitat preference. I also predict *C. curtipennis* will have a higher preference in the wet tallgrass grasslands because during daytime elevated temperatures, when they can be seen on the tops of these particular grasses. As temperatures fall, I predict they will also be abundant in the wet textured grasslands due to the fact they take cover under grasses as temperature decreases. In overall habitat choice I predict it will have a more consistent choice within the wet habitat.

Based on the lack of knowledge of *P. brachyptera*, predictions of habitat can be made simply based on the types of habitats in which they have been recorded in. *P. brachyptera* has been present in xeric, extreme-dry habitats throughout the United States (Johnson 2003). Because they have been seen in both wet and dry habitats, predicting their habitat preference is more abstract. However, I predict they will show an overall preference for dry grasslands. As far as consistency, I believe that this species will remain in the dry habitat and will not be influenced to change habitat when *C. curtipennis* is present.

Within the combined grasshopper treatment, I predict both will types will maintain choice within their habitat preference, despite the influence of a different species. If there is a significant change in preference, I predict it will mostly be due to change in site which may have factors such as different temperature or different textured grass.

The major goal of this study was to determine whether various habitat factors along edges impose a significant impact on grasshopper habitat choice within grassland communities. If grasshopper choice is demonstrated to be influenced by habitat, more advanced studies concerning the specific factors influencing their selection may be analyzed.

Materials and Methods

Grasshoppers for this experiment were collected in the last week of July on the National Bison Range located in Moiese, Montana. The grasshoppers were caught using an insect net while sweeping it along tall and short grasses within the triangle area of the range. Grasshoppers were then separated into species and then sexed. Within the grasshoppers captured, a random sample of fifty grasshoppers (within each species) was chosen to measure their length in millimeters. to give an estimate of the sizes used for each species.

Edges in this experiment were chosen within the prairie vegetation that displayed abundance in both wet and dry grasses. This study site has been previously used in studies by Belovsky et al. 1990, which recorded dominant species of *Poa pratensis* and *Elymus smithii*, species that inhabit the specific grasslands that aided in visual selection of the edge habitats.

Habitat preference of the two grasshopper species (*C. curtipennis* and *P. brachyptera*) was studied by using a joint pair of aluminum insect screen cages (0.01m^2 base and 0.90m height). 27 pairs of cages were connected with a 15 centimeter tube made from the same screen as the cages. This tube was placed on the edge separating both types of vegetation (wet and dry) and served as a passageway to the grasshoppers that allowed access to both habitats. Approximately 7 cm at the base of each cage was buried into the ground in order to insure stability of the rest of the cage, which was further secured with 2-ft stakes. The natural vegetation below the cage was left intact for the purposes of this study. The open top of the screen cage was then folded and fastened with clips to eliminate grasshopper escape or foreign species invasion. These cages were placed on specific natural grassland patches that contained both wet and dry textured grass, with palpable separation between the two flora in order to support this study in comparing two different grasslands. Three replicate sites were identified and used in this study, with each site including three treatments of different grasshopper species composition. 1) The first treatment consisted of a joining cage stocked with 10 grasshoppers of only *C. curtipennis*. 2) The second treatment contained 10 grasshoppers of solely *P. brachyptera*. 3) The third treatment was stocked with a mix of five grasshoppers from the *C. curtipennis* species and five from the *P. brachyptera* species. Within each of the three chosen sites, there were three replicates of each treatment for a total of 9 cages at each site (Figure 1).

On the evening prior to the first day of observation, the grasshoppers were separated into their respective treatments and then randomly separated into two groups of five and placed into either side of the cage to avoid bias composition. The grasshoppers were placed in the cages the night before in order to allow at least twelve hours of acclimation and time to investigate both habitats within each cage.

Habitat selection was measured by surveying the number of grasshoppers present in each side of the 27 joint cages (54 individual cages total) within the three site set up. In addition to habitat selection in the individual cages, mortality was recorded and the side where they perished was counted as their habitat choice. This survey was performed each morning and once each evening at 0900 and 1700 hrs for seven consecutive days. Deceased grasshoppers were not replaced in this experiment in order to model the mortality rate that would occur in a natural habitat.

To verify whether or not the wet side was truly wetter than the dry, soil moisture samples were collected from both sides of each cage in order to confirm the amount of water present in the soil. Samples were brought back to the lab, weighed when wet, then weighed again after they were dried. The difference in water within the soil was recorded.

Air temperature was recorded at the beginning and end of each survey at both times of the day to see if fluctuation in temperature influenced grasshopper choice of habitat.

Following the last day of observation, 12 uniformly distributed point counts were performed at three randomly chosen cage pairs at each of the three sites (18 counts total). Plants within chosen points were identified to species level and counted. This survey was performed in order to estimate the vegetation species present in the cages, which may be a factor in grasshopper habitat selection and in addition, it could show justification in the visual selection of dry and wet habitats in this project.

Results

All statistics within this study were analyzed using the statistical program SYSTAT 10. To test average grasshopper length between species and sex of species, a two-way ANOVA was performed. To test variation in soil moisture between wet and dry habitats and across all three sites, a two-way ANOVA test was performed. To demonstrate the vegetation compared in this study, a count of the number of plant species present in both habitats was taken and graphed. Temperature was averaged and graphed according to date and time of day (either morning or evening). To test habitat selection between the two habitats and between the two species, a two-way ANOVA was used.

Grasshoppers

To distinguish the difference in length of species and within the sex, a two-way ANOVA was performed (Figure 2). Statistics show that within the *C. curtipennis* species, females on average were longer than males. Within the *P. brachyptera* species females were also seen to be longer on average (df = 1 f = 101.233 p > 0.0001). Between both species, *P. brachyptera* were on average longer than *C. curtipennis* (df = 1 f = 209.221 p > 0.0001).

In order to determine which species had a higher mortality rate, a cumulative count of the number of each species still present at the end of the experiment was performed and recorded. The total number of surviving *C. curtipennis* out-numbered those that survived from the *P. brachyptera species* (Figure 3).

Habitat

In regards to site variance, soil moisture was tested using a two way ANOVA to compare percent water content within habitats (wet v. dry) and within site (Figure 4). Sites varied in the level of difference between wet and dry habitats (df =2 f= 5.289 p=0.008). However at all three sites, wet habitats were significantly wetter than the dry habitats (df=1 f=11.164 p=0.002). When comparing habitat and site against water content, there was a non-significant interaction (df= 2 f= 0.582 p=0.563).

Within the vegetation survey taken in 9 of the 27 cages, it was found that *Elymus smithii* and *Poa compressa* dominated the total point counts (216) that were taken in the wet habitat and *Bromus mollis* and *Bromus tectorum* similarly dominated within the dry grasslands (Figure 5).

Temperature

Temperature in the morning and in the evening fluctuated over the seven days of the experiment. The highest temperature was recorded at 37.25 degrees Celsius on the 28th of July at 1700 hrs. (Figure 6).

Habitat selection

Habitat selection for the two grasshopper species was measured by tallying the number of species that chose the wet and those that chose the dry each day (Figure 7). Data was compiled in the following sequence: Date, time period, cage, species and both wet and dry count for the day. Deceased grasshoppers were counted as choosing the habitat where they perished. Once this total number was added, the number of those in the wet habitat for that particular day was divided by the total number of grasshoppers in the cage. This percent was distinguished as ‘rep 1…2…3...4...etc…’ up to rep 18, representing the number of cages at each site (9) X the time periods (morning and evening) =18. From here, the average was taken and standard error was calculated. There was a significant relationship in habitat choice between grasshoppers throughout the seven day trial (df = 3 f = 12.412 p < 0.001).

C. curtipennis alone

Statistical analysis showed that while in the independent treatment, *C. curtipennis* chose the wet habitat for a majority of the seven day experiment. On the first day, there was a definite wet habitat choice. By the second day there was an even number of species in both habitats. The third day showed there was a higher selection in the dry habitat. On days four, five and six the species had chosen the wet habitat as its preference. On the last day of the experiment, *C. curtipennis* displayed an even amount of choice between the wet and dry habitats.

C. curtipennis in mix

Within the mixed treatment, *C. curtipennis* consistently chose the wet habitat as its preference. The first two days showed a definite wet habitat choice. Days three and four showed an even number of species in both habitats. On days five through seven, *C. curtipennis* consistently chose the wet habitat.

Statistics show that *C. curtipennis* maintained its habitat preference both within the independent treatment and the mixed treatment.

P. brachyptera alone

Statistical analyses confirm that within the independent species treatment, *P. brachyptera* did not show a definite habitat choice during the seven day experiment. On the first and second days there was a definite selection of dry habitat. On days three through five, there was an even number of species in both the wet and dry habitats. By day six, *P. brachyptera* had chosen the wet habitat and by the seventh day, there was an evenly distributed number of species in both habitats.

P. brachyptera in mix

Within the mixed species treatment, *P. brachyptera* consistently displayed no preference in habitat selection throughout the experiment. The experiment began with a choice of dry habitat for the first two days. On the third, fourth and fifth day there was an even number of species in both the wet and dry habitats. On day six *P. brachyptera* showed a preference for the wet habitat and by the last day there was an evenly distributed number in both wet and dry habitats.

Statistical analyses show that *P. brachyptera* maintained an evenly distributed amount of species on the wet and dry habitats. It showed no clear preference in habitat selection.

Discussion

The experimental results in this study indicate that both species of grasshoppers, whether in the independent species treatment or in the mixed treatment, chose a specific habitat at least one of the days within the seven day study. As expected per the stated hypotheses, *Chorthippus curtipennis* chose the wet habitat consistently throughout the seven day experiment both while in its independent treatment and in the mixed treatment. However, contrary to the proposed hypotheses, *P. brachyptera* did not show a clear preference for the dry habitat either in the independent species treatment nor the mixed. During the 7 day experiment, *P. brachyptera* (on average) displayed an evenly distributed decision between the wet and dry habitats. Several contributions within these grasslands could have influenced species movement and habitat selection.

Average length between species may have acted as a factor in habitat selection via species competition. From other studies it is known that when grasshopper species compete, the larger species is the superior competitor but also shows declination of competition intensity (Belovsky and Slade 1993). In this experiment, *P. brachyptera* was proven to be the larger species and perhaps was the superior competitor. This species confirmed an evenly distributed choice in wet and dry habitats which could be attributed to adaptability to different environments, thus making its survival rate more successful. However, statistics show that although *P. brachyptera* was able to survive in both grasslands, it had a higher mortality rate when compared to *C. curtipennis*. *C. curtipennis* is known to be a grass specialist that is an efficient consumer of vegetation resources (Beckerman 2000). In Beckerman’s 2000 study, *C. curtipennis* decreased the competitor’s abundance when grass was the resource shared by the other consumer. This was an example where the grass specialist (*C. curtipennis*) excluded the generalist from the environment through competition. This perhaps could be the explanation in this study. With support to the statistical analysis in this study, (although smaller in size) *C. curtipennis* was the superior competitor in this species interaction, facilitating *P. brachyptera* movement to either the dry or the wet side and having a reduced mortality rate.

In this experiment, both species of grasshoppers were observed in the dry habitat, which statistically had lower percent water content in its soil. I believe they both inhabited this grassland because exposed soil can provide sites where grasshoppers are able to bask (Gardiner et al 2002). This could be one influence that attracted the grasshoppers to its environment. To the opposite, moist grasslands and meadows with high soil moisture act as food resource and aid in protection from predators (Craig et al. 1999). This could be the influence that attracted the grasshoppers to the wet habitat.

Skinner and Child (2000) reported that the relative importance of soil characteristics in comparison with other abiotic factors on grasshopper communities is unknown. This is a crucial statement in reference to this study. As an abiotic factor that showed significance in habitat selection, I agree that further studies need to be made to determine how and in what capacity soil moisture can influence habitat choice.

Vegetation structure significantly acted as a factor in habitat selection. Known to choose wet habitats, *C. cutripennis* consistently did so throughout the 7 day experiment, both in the independent and mixed treatments. *P. brachyptera* showed consistent even distribution of wet and dry habitats. Dry vegetation selection could be accredited to various factors. Craig et al. 1999 hypothesized that most grasshopper species require dry and warm open ground for both survival and reproduction. Although reproduction in this study was not observed, this could be an explanation for both species presence in the dry habitat.

Another instance could be that sparse vegetation provides better environmental conditions for daytime activity (Gardiner et al. 2002). This may include basking, foraging, reproduction rituals, or basic mobility. The last example of dry vegetation choice is edge effect. Fagan et al. 1998 reports that immigrant crossing into habitats occurs subsequent to ‘supersaturation’ of a habitat that animals flee as resources are exhausted. This could explain why both species chose the wet vegetation. As plant density decreased, the species instinctively moved to the remaining side where vegetation was still present and available as food resource and predation cover.

An explanation why both species chose wet vegetation is because dense and tall vegetation provides abundant food sources (Gardiner et al. 2002). Throughout the 7 day experiment, the dry vegetation probably exhausted, resulting in both species foraging on the wet plant species, which could give explanation to the evident movement of all four species treatment (*C. curtipennis* alone and in mix, *P. brachyptera* alone and in mix) into the wet vegetation during the last days of the experiment.

Lastly, (although not statistically proven) temperature could have been a factor in habitat choice. Temperature has been shown to have both direct and indirect effects on grasshopper development and survival (Skinner and Child 2000). All specimens used in this experiment were mature adults, but exact instar of each grasshopper was not recorded. Because development stage was unknown, it is a possibility temperature could have influenced certain grasshoppers to choose a specific habitat. A more comprehensible reason to why grasshoppers chose a certain habitat based on temperature could be their body's reaction to the fluctuating temperature. As stated before *C. curtipennis* exhibits increased activity during high temperatures throughout the day and as the temperature falls, they usually take cover under grasses in order to maintain body temperature (Pfadt 1994). Because daily movements of *P. brachyptera* are unavailable, their ability to adapt in various environments must act as their observed behavior. Due to this adaptability, I believe they are able to withstand a range of temperatures, thus explaining their consistent choice of both wet and dry vegetation.

In conclusion, there were multiple factors that may have influenced grasshopper habitat choice within this 7 day experiment. Previous studies have shown that these same aspects influence habitat selection. I believe this study is unique because of the added element edge effect between the two grasslands. This not only made habitat selection more evident, it also displayed a better understanding as to which habitats these specific species are able to survive in. Given results, there is new knowledge that could aid in the preservation or control of these grasshoppers species. Other elements such as biomass, vegetation height, survival rate between sexes, precipitation, soil chemistry, and predator presence could assist in determining grasshopper habitat selection. In closing, further studies are needed in order to support the results of this experiment.

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Literature Cited

Beckerman, A.P. 2002. Counterintuitive outcomes of interspecific competition between two grasshoppers along a resource gradient. *Ecology*, Vol. 81, No.4. pp. 948-957.

Belovsky, G.E. and Slade, J. B. 1993. The role of vertebrae and invertebrate predators in a grasshopper community. – *Oikos* 68: 193-201.

Craig D.P., Bock C.E., Bennett B.C., Bock J.H. (1999) Habitat relationships among grasshoppers (Orthoptera:Acrididae) at the western limit of the Great Plains in Colorado. The American Midland Naturalist: Vol. 142, No. 2 pp. 314–327.

Fagan, William F. Cantrell, Stephen R. and Cosner, Chris. (1999) How habitat edges change species interactions. The American Naturalist. Vol. 153, No.2.

Gardiner, T. Pye, M. Field, R. and Hill, J. The influence of sward height and vegetation composition in determining the habitat preferences of three *Chorthippus* species (Orthoptera: Acrididae) in Chelmsford, Essex, UK. 2002. *Journal of Orthoptera Research*. 11(2): 207-21.

Joern, A. 1982. Vegetation structure and microhabitat selection in grasshoppers (Orthoptera; Acrididae). *Southw. Nat.,* 27:197-209.

Johnson, Dan L. 2003. Slant-faced grasshoppers of the Canadian Prairies and Northern Great Plains. *Arthropods of Canadian Grasslands* 9; 5-16.

Pfadt, R.E. 1994. Field guide to the common western grasshoppers (second edition). Wyoming Agricultural Experiment Station, Bulletin 912, University of Wyoming, Laramie, Wyoming. Fact sheets.

Skinner, K. and Child, D.R. 2002. Multivariate analysis of the factors influencing changes in Colorado grasshopper abundances. *Journal of Orthoptera Research.* pp.103-109.

Squittier, J.M. and Capinera, J.L. 2002. Habitat associations of Florida grasshoppers (Orthoptera; Arcididae). Department of Entemology and Nematology, University of Florida, Gainsville, FL; Vol. 85, No.1 pp.235-244.

Yahner, R.H. 1988. Changes in wildlife communities near edges. Conservation Biology 2:333-339.

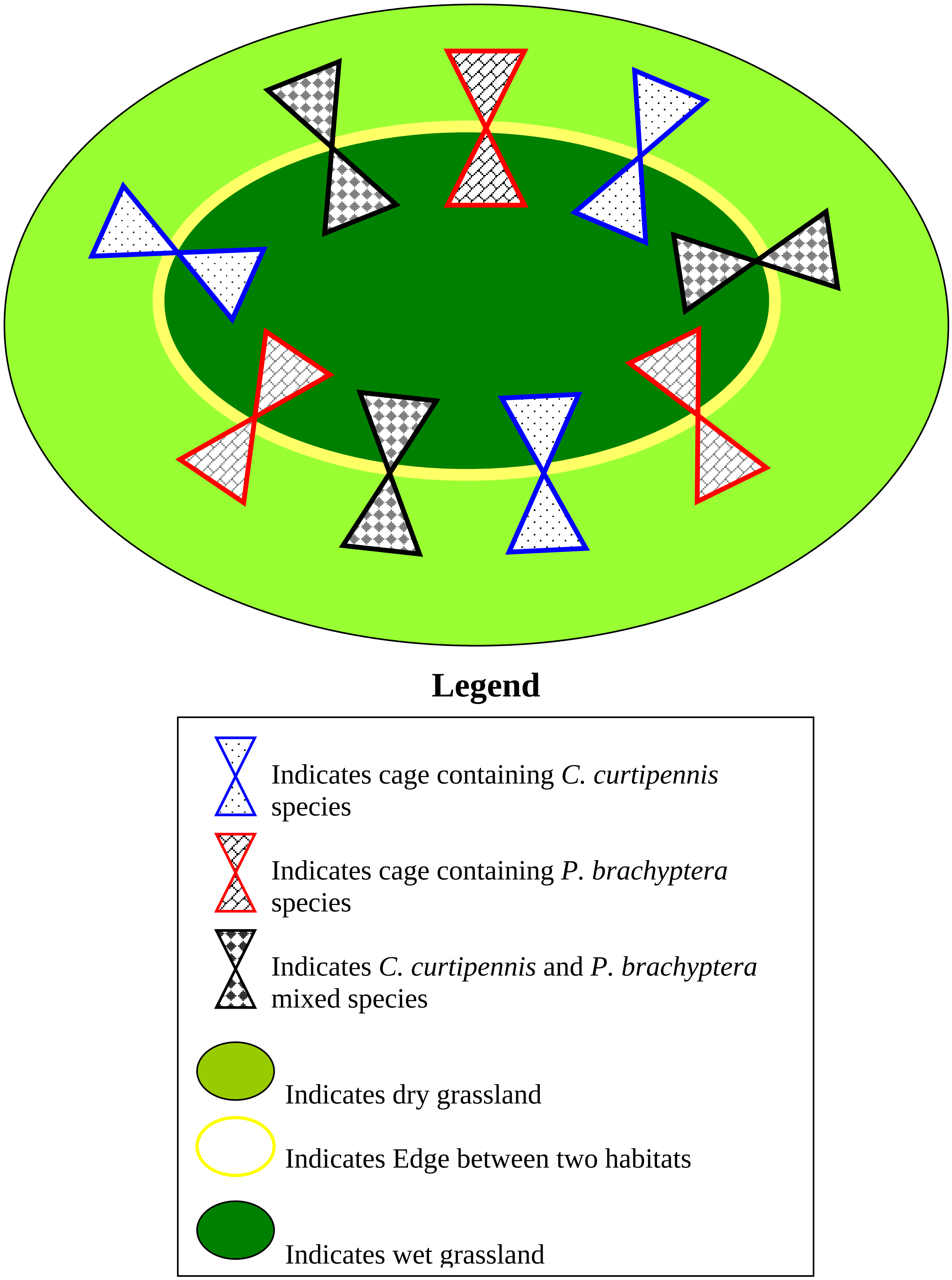

Figure 1. This diagram represents one (1) study site used in this experiment. There were a total of three (3) sites. It illustrates the visual set up of edge separation.

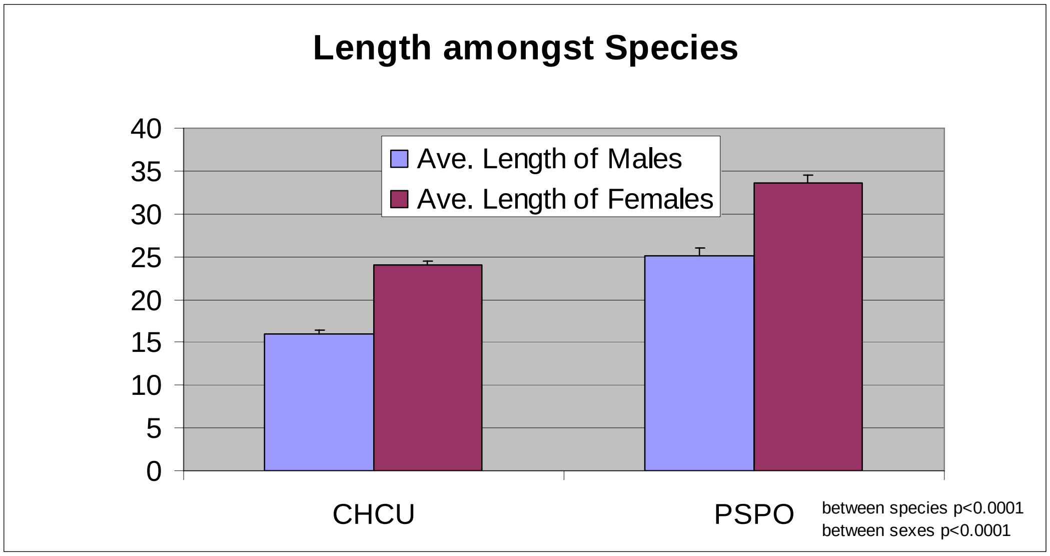

Figure 2. This graph represents the significant difference in length between species ($df = 1$ $f = 209.221$ $p < 0.0001$) and between sexes ($df = 1$ $f = 101.233$ $p < 0.0001$).

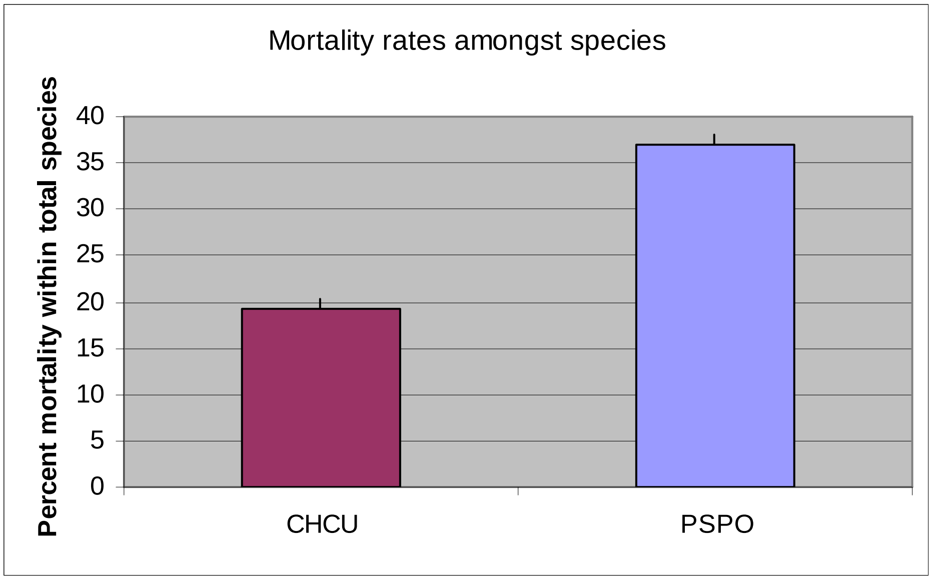

Figure 3. This graph shows the percent mortality between the two species. It is apparent the *P. brachyptera* had a higher mortality rate (37% of total species) when compared to *C. chorthippus* (19.3% of total species) .

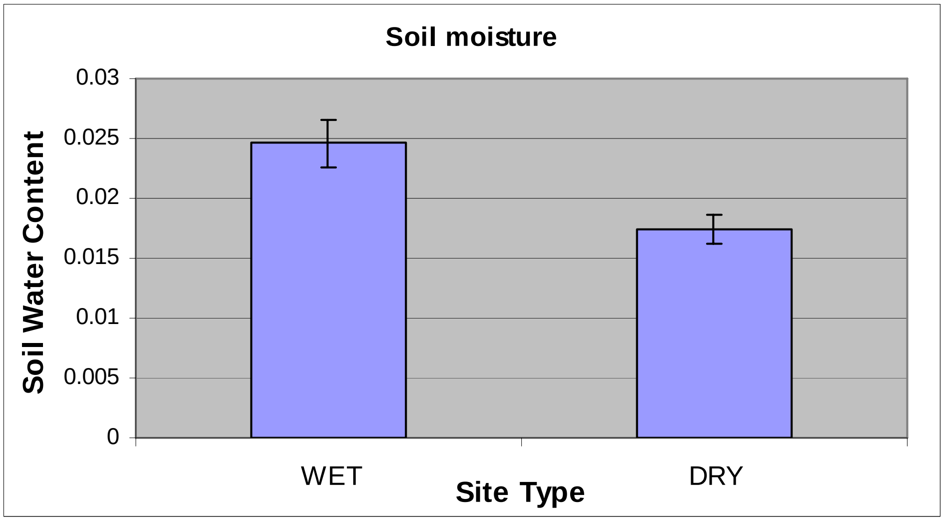

Figure 4. This graph shows the difference between soil moisture and site type. This study displayed a significant relationship between percent water content and habitat (df = 1 f = 11.164 p = 0.002) and between percent water content and site (df = 2 f = 5.289 p = 0.008).

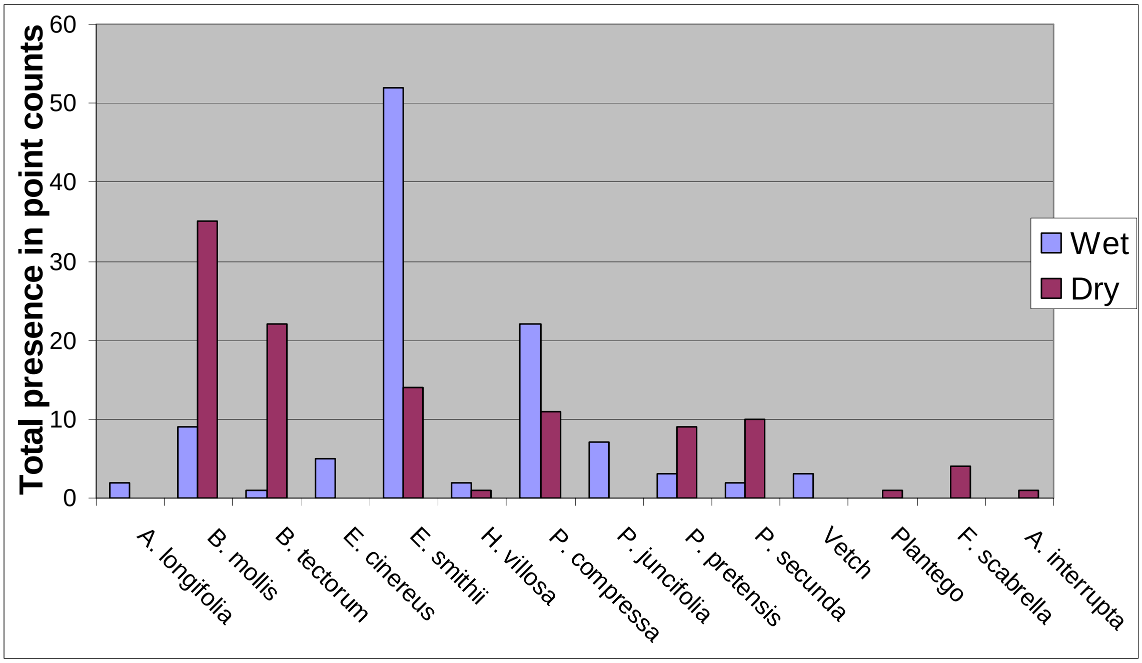

Figure 5. This table represents the different types of vegetation that was identified in both the dry and the wet sections of the 12 point count. The 12 point count was performed in three of the nine cages present at each site (3 sites total). There were a grand total of 216 point counts.

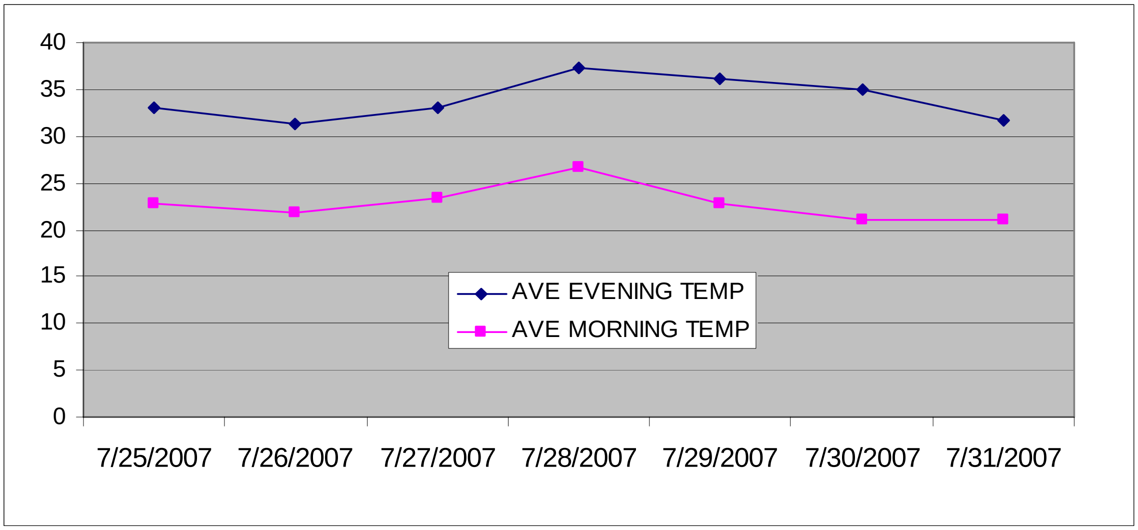

Figure 6. This graph represents the average temperature starting Wednesday, July 25th and ending Tuesday, July 31st. These temperatures were taken at the beginning of observation each morning and evening.

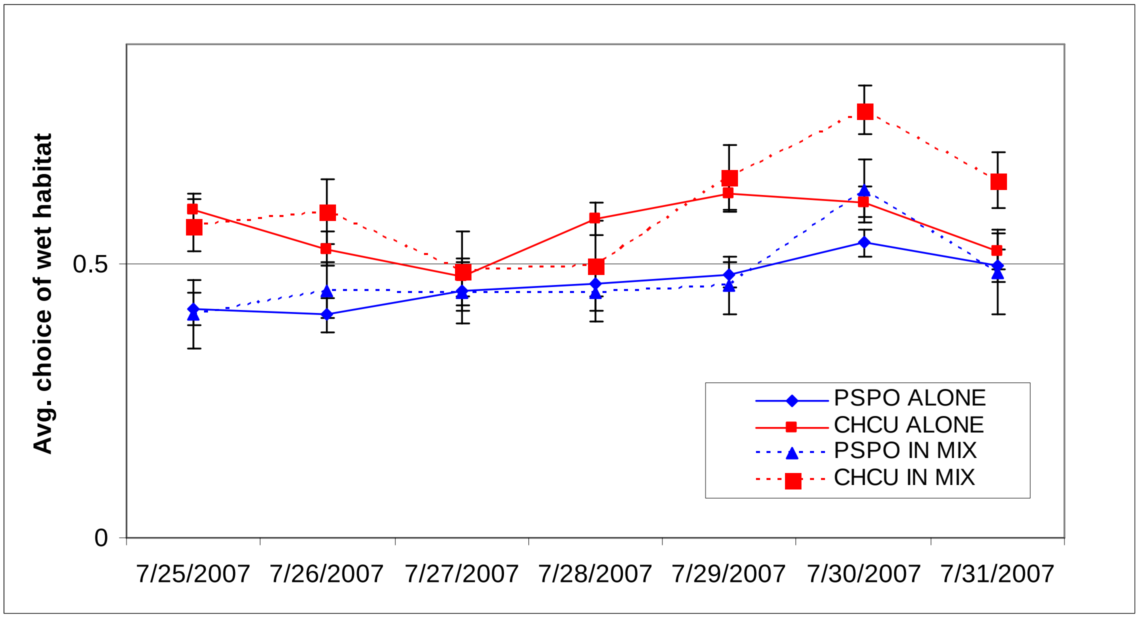

Figure 7. This graph represents the average choice of wet and dry habitats within both species of grasshoppers throughout the seven day observation. Results indicated there was a significant value in choice (df = 3 f = 12.412 p < 0.001).