Distribution of Grasshopper Parasitism at the National Bison Range

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Introduction

Grasshoppers (Oder Orthoptera, Suborder Caelifera, Family Acrididae) are some of the most abundant terrestrial insect species in grassland ecosystems (Capinera et.al. 2004), playing an important role in determining grassland ecosystem structure and function. This includes influencing the nutrient cycle (Belovsky & Slade 2000), primary productivity (Belovsky & Slade 2000), influencing food dynamics by providing food for many predator species (Beckerman 1997) and, when populations are overly abundant, pests (Branson et.al. 2006). Grasshoppers can be parasitized by a range of parasites and parasitoids (hereafter referred to collectively as "parasites"), which can influence their abundance. Because of this, studies have been conducted to better understand grasshopper ecology, their interactions with parasites and what factors might influence grasshopper populations dynamics(Branson 2003).

Factors that play a role in fecundity, survival and dispersal of the individuals of a species, influence the abundance of a population (Joern 2004). Parasites have been shown to affect all three of these factors (Laws 2009; Danyk et. al. 2005; Mongkolkiti & Hosord et al. 1971). Understanding how parasites can affect such important species can help efforts to manage grasshoppers and for sustainable grassland ecosystems. One aspect of this is understanding how the distribution of parasites changes over space and time.

Just like any other organism, parasites are suscepotible to their environment (Cheng 1986). Parasites are expected to be in regions that are favorable for life in general (Pedigo 2004). This means that theyr are most likely to be found in areas with environmental factors capable of providing specific basic requirements for their living. This could be their microenvironment, which are factors involving the host, including host specificity, host diet and immunology. Different habitat sites, with varying characteristics, like grazing and fire, can have effects on variables that directly affect grasshoppers (Arenz & Joern, 1996; Panzer, 2002; Joern, 2004; Laws & Joern 2012). Is its macroenvironment, which is in direct relation to the host, as well as all the factors that might be important on the parasite's life cycle before reaching its host (Cheng 1986). Parasites will be most abundant in environments that provide the best micro-and macro-environmental variables for the host and the parasite (Pedigo et. al. 1970).

There is a lack of studies examining how host-parasite interactions in grasshoppers vary over space and time**.** In this project I looked at the spatial distribution of parasitism in grasshoppers at the National Bison Range, MT while looking at the macroenvironmental that might influence the abundance of parasites. I measured the grasshopper community composition, parasite presence, and physical, macroenvironmental characteristics of ten sites on the National Bison Range. I hypothesize that there will be certain patterns between parasite infection and macroenvironmental factors. I expect to find nematode parasites in wetter soils, as well as near water bodies (Mongkolkiti & Hosord et al. 1971). I expect highest abundance of mites in sites with high grasshopper populations (Steinhaus et al. 1958). For dipteran parasitoids, I expect to find in sites with higher abundance of flowering plants due to their sugar limitation (Tena 2015).

Methods

This project was conducted during the summer of 2015 at the National Bison Range(NBR) in Montana. The NBR is comprised of 18,500 acres reserved to support a population of around 400 American bison (*Bison bison*). It is mostly palouse prairie and rolling hills. During the summer, I visited 10 different sites, on three different occasions during the summer, with about 2 weeks of separation between each sampling time. All of the locations were distributed all over the NBR, to obtain a better representation of the area. This was done to capture the heterogeneity of the NBR influenced by the separation by physical barriers like elevation, proximity to forests and water bodies, as well as separation by mountains.

To assess the environmental conditions that might affect parasitism prevalence, a series of physical factors were recorded at all sites. The elevation and site were recorded with a GPS unit. A 200ft (60.96m) transect was layed out on every visit, with 1 plot for every 50ft (15.24m). Vertical plant cover was be assessed with a meter stick using the “toe-point” system, while horizontal coverage was measured with a row-boat stick, all on each plot. Five soil samples were collected per site and tested for water content. Other factors recorded will be: closeness to water bodies, bison grazing, soil vs rocky ground and predominant plant types (grasses, forbs, shrubs and flowering plants).

On each of these sites, grasshoppers will be collected by sweep-netting 30 sweeps on five transects. All the grasshopper individuals were frozen and stored to avoid the destruction of any body parts. They were identified down to family, genus and species. Size, sex, weight and size of pronotum were recorded. Life stage of the individuals was classified between early instars (1^{st}, 2^{nd} & 3^{rd} instars all together), late instars (4^{th} & 5^{th} instars separately), and adults. Early instars were recorded only to study community composition, but were not dissected in search of internal parasites. On late instars and adults, the presence of the ectoparasitic organism *E. locustorum* (mites) was recorded for with the use of a dissection microscope. After this, grasshoppers were dissected to look for nematodes and dipteran parasitoids.

To perform statistics (ANOVA, Multiple and Linear Regression), the computer software Systat (Systat Software Inc.)

Results

Community:

A total of 1162 grasshoppers were collected. The species present in the sites were *Ageneotettix deorum, Amphitornus coloradus, Arphia pseudonietana, Camnula pellucida, Chortipus curtipennis, Melanoplus bivittatus, Melanoplus dawsoni, Melanoplus femurrubrum, Melanoplus sanguinepes, Metator pardalinus, Pseudopomala brachyptera, Trachyrachys kiowa, Trimerotropis verruculata suffuse* and *Trimerotropis Fontana*. Amount of individuals per species, relative abundance and diversity index by site are presented in Table 1.

Some communities seemed to have similar community composition across the summer. According to the Principal Component Analysis(Image 1), communities at the sites Triangle, Triangle 2, Corral and Pauline 2 were the most similar. This seemed to be caused by elevation and general location, since three of these four sites were located in close-by areas, and their elevation was not too different (778-823ft). Other similar communities were the ones at High Point, Trisky, Tower 1 and Tower 2, which were also influenced by elevation (1241-1486ft). A multiple linear regression showed that, out of all the environmental factors measured, only elevation (p value: 0.048) and soil moisture (0.045) had significant impacts on community composition.

Parasitism:

Only 5.67% of the total grasshopper population had any form of parasitism, being mites the most abundant form of parasitism (Graph 1). A total of 2 nematodes, 23 dipteran parasitoids and 142 mites were found parasitizing grasshoppers, with *Melanoplus sanguinepes* being the most commonly infected species (6.97%). None of the parasites showed to have a preference in host size. There was also no correlation between overall parasitism and grasshopper density (p value of .744). There were no significant differences between overall parasitism and sampling time (p value <0.201).

Elevation was demonstrated to have an effect in overall parasitism (p value< .015), while water percentage in soil came to significance with a p value<0.061. Both of these factors seemed to have positive relationships with parasitism.

Mite parasitism proportion did not have any relationship with grasshopper abundance at sites (p value<0.935). Mite parasitism proportion did not increase throughout the summer in any of the sites except for High Point (Graph 2). When tested against abiotic factors, again elevation (p value<.009), and water percentage in soil (p value < .057) were found to have any significant effect. However, ground also seemed to have an effect with a 0.13 p value.

For both, overall proportion of parasitism and mite parasitism the species *Amphitornus coloradus* seemed to have a positive relationship.

Discussion

Elevation was the abiotic factor that played the strongest influence over community composition, overall proportion of parasitism and mite parasitism. Water percentage in soil was also a really important determining factor for parasitism.. The fact that *Amphitornus coloradus* appeared to have a positive relationship with parasitism, while not being infected in any of the sites, could mean that *A. coloradus* is serving as an indicator for some other factor that is related to parasitism abundance. It is possible that, due to the specialist nature of this grasshopper's diet (Joern 1985), parasitism could be being driven by the presence of certain grass species. Other than this, there were no significant trends in parasitism distribution. This could mean that parasitism is being influenced by another environmental factor, that was not measured in this study.

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Systat Software, Inc., San Jose California USA, www.sigmaplot.com

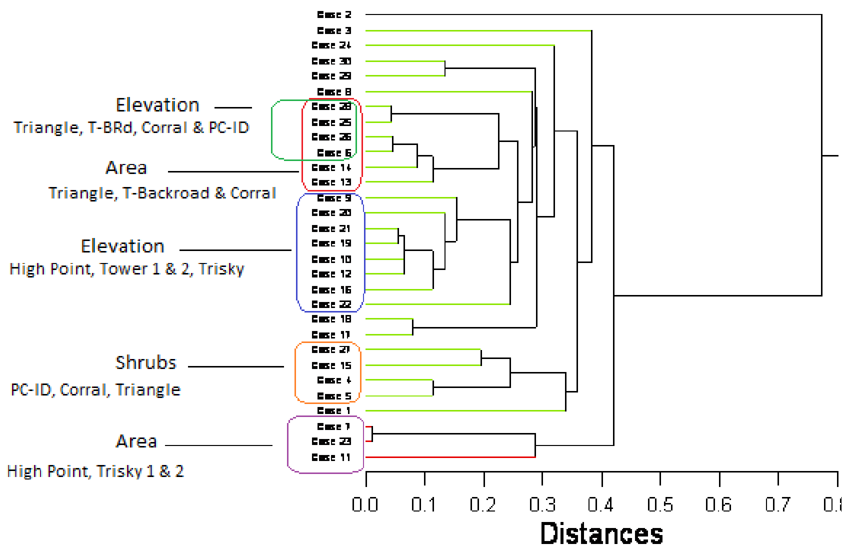
Images

Table 1. Amount of Grasshoppers collected at each sampling, Diversity Index and Evenness

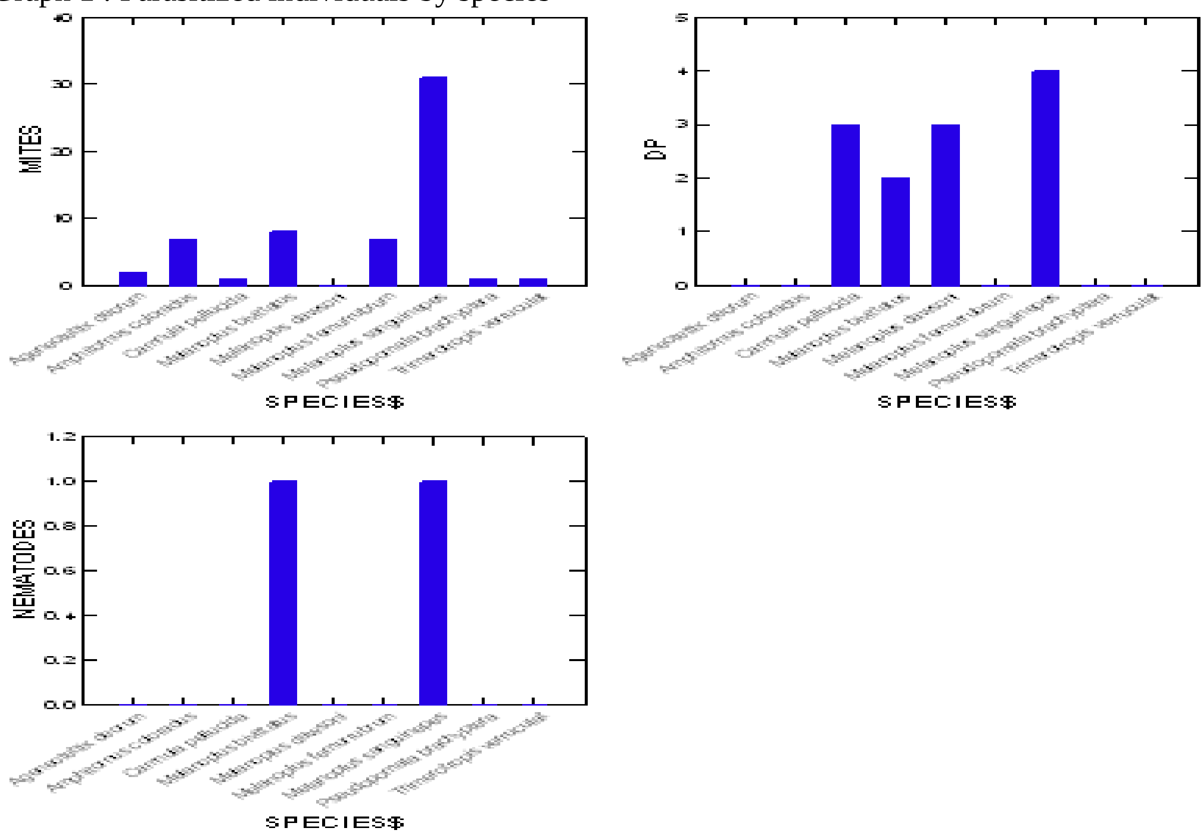
Site	Sample	Grasshoppers Collected	Diversity Index (Shanon-Weiner)	Evenness
1	1	40	1.24	0.894
1	2	32	1.1	0.614
1	3	19	1.663	0.855
2	1	27	1.699	0.873
2	2	27	0.739	0.533
2	3	25	1.149	0.829
3	1	35	1.611	0.89
3	2	48	0.779	0.562
3	3	35	1.282	0.715
4	1	36	0.254	0.231
4	2	83	0.233	0.212
4	3	44	1.095	0.997
5	1	30	0.636	0.579
5	2	13	1.117	0.805
5	3	20	0.948	0.865
6	1	44	0.46	0.332
6	2	39	0.831	0.599
6	3	39	0.584	0.531
7	1	44	0.499	0.36
7	2	33	0.657	0.474
7	3	40	0.64	0.397
8	1	68	0.859	0.533
8	2	50	1.045	0.583
8	3	36	1.43	0.798
9	1	50	1.056	0.656
9	2	88	1.44	0.74
9	3	29	0.864	0.786
10	1	39	1.051	0.653
10	2	28	1.486	0.829
10	3	22	1.441	0.895

Image 1: Cladogram showing Community similarities

Grasshopper Communities



Graph 1 : Parasitized individuals by species



Graph 2: Proportion of Mite parasitism over time on each site