Examining red mite infection and the outcome of competition between *M. dawsoni* and *C. pellucida*

BIOS 35502: Practicum in Environmental Field Biology

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Abstract:

Grasshoppers are common insect herbivores important to grassland ecosystems across the world. Grasshopper herbivory can have huge effects on the environment such as accelerating or slowing nitrogen cycling which in turn can affect primary plant production. Herbivory patterns are determined by grasshopper species composition, which is affected by competition between grasshoppers. This experiment examines interspecies and intraspecies competition between *M. dawsoni* and *C. pellucida*, two grasshopper species that coexist in abundance at the University of Notre Dame Environmental Research Center. This field experiment examines some of the factors that affect the outcome of the competition. The results of the study revealed that *C. pellucida* outcompetes *M. Dawsoni* when both species are present in equal ratios. This outcome may be the consequence of infection of the red mite pathogen, which exclusively fed upon *M. Dawsoni* throughout the experiment. These results necessitate further research on the effect of red mite parasites on grasshopper competition in order to completely understand the subject.

Introduction:

Grasshopper populations have a profound impact on the ecosystem by affecting factors such as nutrient cycling and plant production (Belovsky and Slade 2000). Competition between grasshopper species plays an important role in determining the composition of grasshopper populations, which in turn affect grassland plant community productivity and composition. One well-documented mechanism of interspecific competition between herbivore species is the ability to consume resources. If two species compete for one resource, the competition is generally dominated by the species that can effectively reduce the resource to the lowest level (Ritchie and Tilman 1992). Pathogens and parasites may also play an important role in determining the outcome of interspecific competition. Changes in interspecific competition induced by a pathogen could lead to changes in grasshopper population dynamics and in turn changes in the ecosystem.

Red mites (Acarina) are a common parasite to grasshoppers all over the United States; however, very little is known about them and how they affect grasshopper population dynamics. There are at least two known species of red mites that parasitize grasshoppers: mites of the wings (*Eutrombidium locustarum*) and mites of the legs and antennae (not formally named). These red mite larvae attach to the exoskeleton of their grasshopper host and suck their hemolymph for 5 to14 days (Branson 2003). This is a direct impairment to infected grasshoppers that has been shown to lead to dramatic reduction in the survival and reproduction of grasshoppers under certain conditions (Belovsky et al. 1999). This indicates that red mites may serve as a useful biological control agent to control grasshopper infestations (Branson et al. 2006).

In addition to pathogens, food preference niches may play a large role in determining the outcome of interspecies grasshopper competition (Chase 1996). *C. pellucida,* a common pest known to infest cereal crops at high densities (Riegert et. al 1964), specializes on grass and does not have the ability to generalize when resources are scarce (Pfadt 1994). *M. dawsoni* preferentially feeds on forbs such as dandelion and ragweed, but they also have the ability to feed on grasses as a secondary food source (Pfadt 1994). This generalization of food sources gives *M. dawsoni* an exclusive food resource in forbs and an advantage when competing with *C. pellucida* scarce. *C.*

pellucida must out compete *M. dawsoni* for grass resources per capita in order for the two species to coexist in the same habitat (Chase 1996). This could play a large role in determining the outcome of interspecific competition between dominant grasshopper species, which in turn could affect grassland plant composition, and biomass (Belovsky and Slade 1995).

In a field experiment, I examined competition between two grasshopper species (*Melanoplus dawsoni* and *Camnula pellucida*) and how parasitic grasshopper mites affect the two species differently. It was previously hypothesized that genetic and behavioral differences between grasshoppers is unlikely to have a significant affect on the probability of infection by mites (Branson 2003). However, upon first-hand observation in the field, there seemed to be a disproportionate number of infected Melanoplinae grasshoppers compared to the subfamily Oedipodinae (Kistner, personal observation). This raised an interesting question on the selectivity of mites and the resistance of grasshopper species to mites. In order to examine this I placed cages of differing grasshopper species in the field and measured the rates at which mites infected them and their rates of survival. If mites preferentially parasitize one species of grasshopper there may be a significant advantage for the more resistant species to prevail in competition and survive at higher proportion.

Another important point of this experiment is to examine if plant biomass was determined by grasshopper composition. If mites infect one grasshopper species in a higher proportion than the other, the infected species may consume more resources to compensate for nutrients lost to the parasite (Washburn et al. 1991). This could possibly create a significant difference in plant biomass and plant community composition depending on species composition. Also, if the mite pathogen causes mortality in one species of grasshopper this could also result in a significant difference in biomass consumed across species composition.

I expected *Melanoplus dawsoni* to survive better than *Camnula pellucida* as a result of their ability to consume multiple food sources; therefore, *M. dawsoni* should outcompete *C. pellucida* and survive at higher rates in all cases. However, I also expected the red mite pathogen to infect *M. dawsoni* at higher rates than *C. pellucida, which* may play a role in determining the outcome of the interspecies competition.

Methods:

This research took place during the summer of 2014 in an old field at the University of Notre Dame Environmental Research Center in Land O Lakes, WI(46° 13' N, 89° 32' W). All grasshoppers were caught and caged on site (grasshopper nation) where grasshoppers and resources are in abundance. *Melanoplus dawsoni* and *Camnula pellucida* are two common grasshopper species found in moderate densities at the site of the experiment (Laws et al. 2009, Laws and Belovsky 2010). Grasshoppers were caught and collected from the site using insect nets, and stored in an aquarium in the lab for three days to eradicate any injured or infected grasshoppers. The infected and injured grasshoppers were omitted from the experiment. Many grasshoppers caught on site were infected with red mites, confirming their existence on site. In order to enclose grasshoppers in their natural environment I used 16 different 0.36 m^2 mesocosm cages similar to those used in other successful studies (Belovsky & Slade 1993, Laws et al. 2009). The cages were placed over natural vegetation and buried into the ground to prevent grasshoppers from escaping and other animals from getting in. I constructed the cages in two transects separated by 2 meters. 8 grasshoppers were randomly stocked in 12 of the cages in 3 differing compositions with 4 replicates for each composition. Three population compositions (*C. pellucida* alone, *M. dawsoni* alone, 1:1 ratio of both species) were necessary to distinguish of any trends in survival rate due to competition between the grasshoppers. The remaining 4 cages were left with no grasshoppers as a control for the consumed biomass measurements. The experiment ran for a total of 11 days. All statistics were performed with R 2.10.1 (R Development Core Team 2009).

Infection: Infection rates by red mites were assessed through direct observation of each surviving grasshopper and noting the presence of mites. The severity of each infection was also noted. I compared infection counts across the two species of grasshoppers with a chi-square test of independence to determine if there is any relationship between grasshopper species and mite infection.

Competition: To assess the interspecific competition between *C. pellucida* and *M. dawsoni* the survival rates of grasshoppers were compared across differing community compositions at the end of an 11 day period. The data was analyzed using multiple t-tests between the data on the final day of the experiment to establish any differences in grasshopper survival based on community composition.

Consumption: Biomass consumed was measured by clipping the vegetation in each cage at the end of the 11 day experiment. After clipping, the grasses and forbs were separated and analyzed separately. The vegetation was dried for 24 hours at 61˚C in an isotemp oven and then weighed. The 4 cages with no grasshoppers served as a control. Differences in grasshopper herbivory were quantified by comparing plant biomass between the control and grasshopper treatments. The data was analyzed using a one-way analysis of variance in order to determine if there was any significant difference in grass or forbs left in each cage based on population composition.

Results:

Infection: Throughout the experiment the proportion of *M. dawsoni* infected with red mites increased steadily; however, the red mites never affected *C. pellucida*. Nearly 50% of all *M. dawsoni* recovered at the end of the experiment were infected with mites. A chi-square analysis of the data from the final day of the experiment revealed a significant relationship between mite infection and species (df =1, $X^2 = 8.3422$, p-value = 0.00387; Table 1).

Competition: Competition between the two grasshopper species was analyzed by comparing the proportion of surviving grasshoppers in the mixed species treatment with single species populations. *M. dawsoni* showed a significant decrease in survival when in competition with *C. pellucida* compared to their survival alone ($\alpha = 0.10$, t = 2.5059, df = 4.726, p-value = 0.05691; Fig. 1). *C. pellucida* followed the opposite trend and survived better when in competition with *M. dawsoni*; however, this affect was not statistically significant (t = -1.7035, df = 4.835, p-value = 0.1512; Fig. 2). A comparison of survival across both species showed that *C. pellucida* survived significantly better than *M. dawsoni* when the two were in competition with each other at equal proportions ($\alpha = 0.10$, t = 2.1501, df = 4.504, p-value = 0.09028; Fig. 3).

Consumption: Analysis of grass and forb biomass remaining in each cage at the end of the experiment revealed no significant relationship between grasshopper species composition and grass or forb biomass (Fig. 4; Fig. 5). The control treatment with no grasshoppers had the highest grass biomass on average and the mixed grasshopper treatment showed the lowest grass biomass on average, but this trend was not statically significant ($F_{3,314.9} = 1.105$; p-value = 0.385). The forb biomass was also relatively equal for each treatment group ($F_{3,314.9} = 0.032$; p-value =0.992).

Discussion:

This experiment revealed important factors of competition and ecotparasitism of grasshoppers by red mites in an old world field. . Red mites clearly infected *M. dawsoni* at higher rates than *C. pellucida*. It is impossible to determine whether this trend can be attributed to preferential feeding by red mites or a resistance in *C. pellucida* from this study alone. However, from the results of this experiment it appears that *C. pellucida* are completely unaffected by red mite infection. Further studies are necessary to determine if these results are applicable to other locations and other grasshopper species.

The results of the survivorship analysis suggest that red mites are playing a major role in determining the survival of *M. dawsoni* when in competition with *C. pellucida*, but not when *M. dawsoni* is alone. *M. dawsoni* performed as expected when faced with intraspecies competition, most likely as a result of their ability to consume both grass and forbs. When faced with interspecies competition *M. dawsoni* survived significantly worse suggesting that the competitor, *C. pellucida*, was outcompeting them for resources. This result was unexpected and may have been caused by red mites weakening the *M. dawsoni* and increasing the necessity of nutrient intake (Washburn et al 1991).

On the other hand, *C. pellucida* seemed to be limited more by intraspecies competition as opposed to interspecies competition. This was most likely caused by the specialist nature of *C. pellucida*, feeding only on grass, but not on forbs (Pfadt 1994). When *C. pellucida* was faced with a weakened competitor in *M. dawsoni* they were able to prevail and survive at higher frequencies even though *M. dawsoni* has the distinct advantage on resource consumption. This experiment alone cannot prove that red mites were the main cause for the survivorship trends in the interspecies competition. Another experiment would be necessary in which there is a mite free *M. dawsoni* treatment in order to determine if red mites are the sole cause of the observed outcome in competition.

Analysis of the biomass left in each cage at the end of the experiment indicates that grasshopper species composition and mite infection have no large affect on consumption by grasshoppers. However, another experiment at higher grasshopper densities and for a longer period of time may change the outcome from what was observed in this experiment.

These results have many implications to better understand grasshopper population dynamics and help predict grasshopper population compositions in the Upper Peninsula of Michigan. Red mites may sufficiently decrease *M. dawsoni* populations that are in competition with *C. pellucida.* Although studies have indicated that pathogens can reduce insect populations (Washburn et al. 1991), this experiment indicates that red mites are not a reliable biological control agent for grasshoppers in competition. However, this study does suggest that the presence and abundance of red mites may serve as a good biological indicator for predicting the outcome of interspecies competition between two grasshopper species that are differentially affected by mites. These changes in grasshopper species composition could have profound effects on the environment; although the results of this experiment did not show any significant difference in consumption based on species composition there may be some effect at a larger scale.

Tables:

Table 1. Red mite infection in relation to grasshopper species. On the final day of the experiment a count of the total number of surviving grasshoppers and number of mite-infected grasshoppers was recorded for each species. A chi-squared test of independence revealed a significant relationship between species and mite infection.

	M. dawsoni	C. pellucida
Mite Free	9	13
Mite Infected	8	0

Figures:

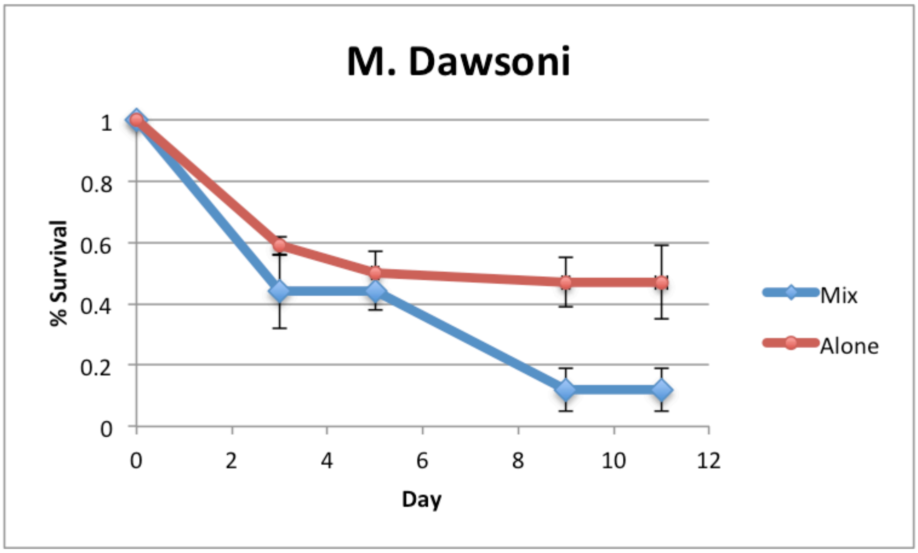

Figure 1. The effect of interspecies competition and intraspecies competition on *M. dawsoni*. Survivorship data shows a trend of higher mortality in cages with both species of grasshopper compared to cages with *M. dawsoni* alone.

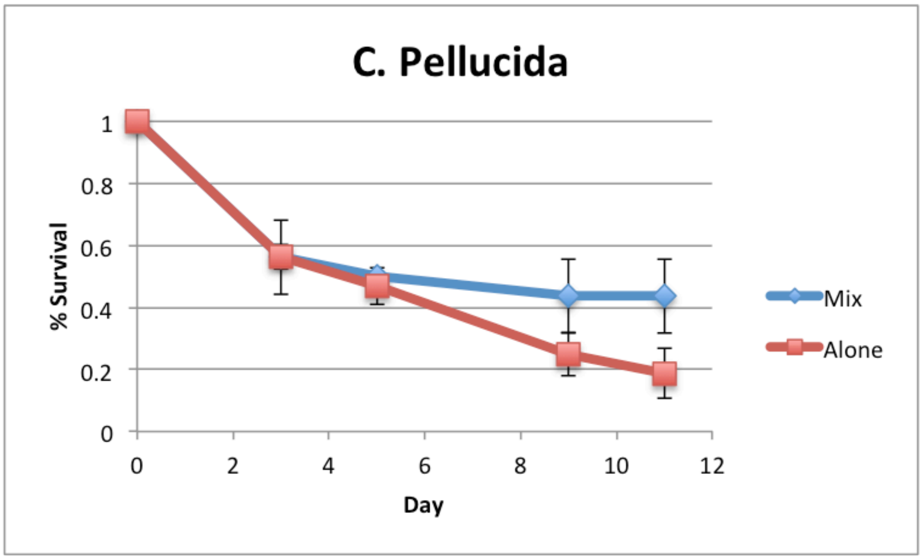

Figure 2. The effect of interspecies competition and intraspecies competition on *C. pellucida*. Survivorship data shows a trend of higher mortality in the cages with *C. pellucida* alone compared to *C. pellucida* and *M. dawsoni;* however, a t-test of the proportions surviving on the final day revealed no statistical significance in survival.

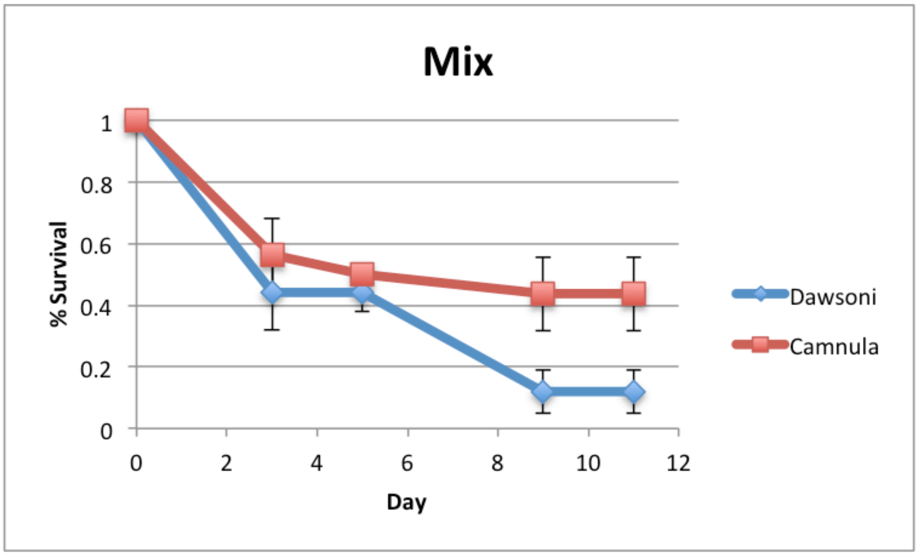

Figure 3. Comparing survival of *C. pellucida* and *M. dawsoni* in competition. The data reveals a trend of higher mortality rates in *M. dawsoni* when in competition with *C. pellucida.*

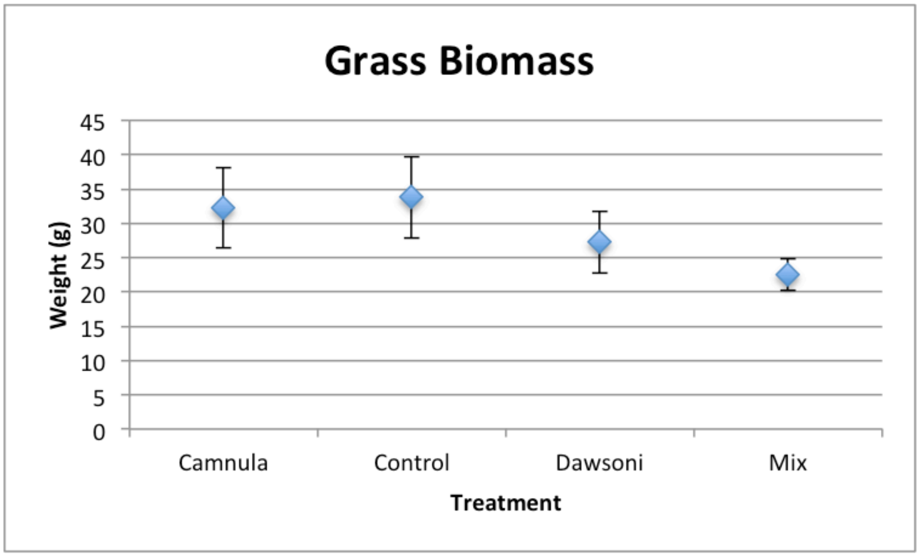

Figure 4. The final dry biomass of grass compared across treatments. Grass biomass did not vary across treatment groups.

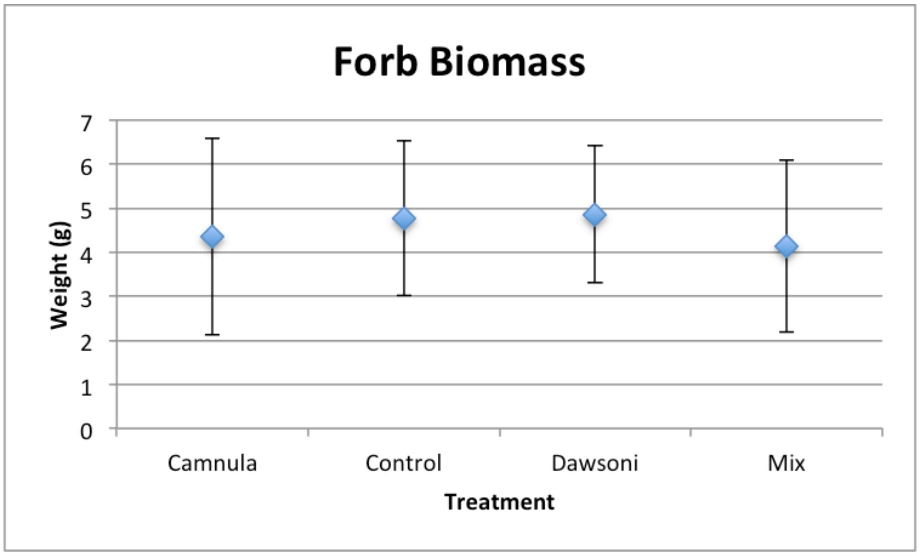

Figure 5. The final dry biomass of forbs compared across treatments. The biomass of forbs was determined to be relatively equal across all treatments.

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