A survey of local grasshopper populations and the effect of mite infestation on *M. dawsoni* survivorship

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Abstract

Due to the potential of grasshoppers to act as an agricultural pest, effective population control methods are an important area of ecological research. Previous studies have shown that factors such as predation, food availability, and pathogen infection can impact grasshopper survivorship. However, little research has examined the potential of ectoparasitic mites as grasshopper bio control agents. I investigated the potential for ectoparasitic mites to serve as a form of pest management by surveying basal levels of mite infestation across different grasshopper species and studying the survivorship of mite infested individuals in field enclosures. The results of the survey suggest mites preferentially prefer hosts in the subfamily Malanoplinae. In the experimental field study, there was no significant difference in survivorship from mite infestation, potentially due to mite contamination of the control. Future studies of the host specificity of ectoparasitic mites and impact on grasshopper populations are needed for a better understanding of this potential form of pest management.

Introduction

As an herbaceous grassland insect, grasshoppers can reduce harvest yields of economically important crops (Branson et al. 2006). Population studies are therefore essential in understanding and controlling grasshopper outbreaks over time. Bio control options are becoming increasingly popular for the management of pest species. However, caution must be used for the introduction of one species to control another, given the potential for the introduced species to become the new pest. Specificity in the relationship between applied bio control and pest species is a useful element to insure non-pests are not negatively impacted by the introduced species.

A few of the known factors that can influence grasshopper populations are predation, food availability, and disease (Moller, 2008). Wolf spiders are one commonly studied grasshopper predator. Predation can increase the mortality rates in grasshoppers directly through prey consumption and indirectly through behavioral shifts to avoid predation that increase the risk of starvation (Schmitz et al., 1997). The availability of food is a limiting factor on population size that has been experimentally shown to impact populations between years as well as in the course of a single season for all age groups (Belovsky and Slade, 1995). Additionally, entomopathogens such as *Entomophaga grylli* have been shown to increase mortality both in field and lab conditions, with local weather conditions being a potential influence on the *E. grylli* outbreaks (Kistner and Belovsky, 2013). Interactions between factors are also an area of interest, as additive or compensatory mortality would impact the efficiency of a pest management program. In additive mortality, additional factors increase overall mortality rates, while in compensatory mortality the overall survivorship is remains stable, with additional factors acting as replacement sources of mortality. In one study, mortality from predation was additive when food was abundant and compensatory when food was scarce (Oedekoven and Joern, 2000). Additionally, when pathogens and predation are combined, predation can increase the population by removing infected individuals at high pathogen levels, but predation becomes a form of additive mortality at lower infection levels (Laws et al., 2009).

Despite parasitic infections being comparable to predation as a source of population mortality, little is known about the specific effects of parasitism on the life history of grasshoppers (Anderson and May, 1978). The use of parasitic mites, both *Eutrombidium* *locustarum* which attaches on the wings and an unnamed species that attaches on the appendages, have been studied for their effect on grasshopper fitness. Interestingly, the effects of mites seem to have an impact on survivorship as well as egg production (Belovsky et al., 1999). The complex life style of mites also includes grasshopper egg predation, making the total impact of the addition of mites to a grasshopper population difficult to quantify. The response of different grasshopper species to mite infestation seems to vary as well, with the potential for an increase in short term competitive ability of one grasshopper species over another being a possible response to parasitism (Anderson, Unpublished Data).

In order to understand the prevalence of mite infestation across grasshopper species, I conducted a survey in an old world field in the Upper Peninsula of Michigan. I hypothesized that a survey of local grasshopper populations will reveal mite prevalence varying between grasshopper species. To assess the implications of the mites on the survivorship of the grasshoppers, I conducted a field experiment comparing mite free and mite infected grasshoppers. I hypothesized that the presence of the mites should reduce survival of *M. dawsoni* nymphs.

Methods

I surveyed the prevalence of mite infestation of one old field at the University of Notre Dame Environmental Research Center in Land O Lakes, WI (46° 13' N, 89° 32' W) through the use of 4 collection periods over the course of three weeks from 7/3/2014-7/16/2014. For each survey, I collected approximately 50 grasshoppers by field netting in the same portion of the field consecutively. I then recorded the species and presence of mites of the collected grasshoppers.

The effect on the survivorship from mite infestation was assessed through comparative mortality rates in a field setting. *Melanoplus dawsoni* 2^{nd}-4^{th} instar nymphs were stocked in ten $0.35m^2$ mesh cages with random assignment for 5 cages infected and 5 cages mite free. *M. dawsoni* is commonly found in the Midwest with hatching occurring during June and early July, with year to year variations depending on the weather. *M. dawsoni* feeds on a mixture of forbs and grasses, with forbs being preferred (Pfadt, 2002). The enclosures used were similar to those used by Belovsky and Slade 1995 as they are effective at containing grasshoppers while allowing for observation. During the trial, I counted the surviving grasshoppers four times over a period of one and a half weeks from 7/8/2014-7/18/2014. For the final count, I noted which grasshoppers were infected with mites.

The statistical program used to analyze the data was R version 3.0.2 (R Development Core Team 2013). For the survey, arcsine(square root) transformed proportion data was used in a one-way ANOVA to determine if the proportion of mite infested individuals varied across species. For the field enclosures, the proportion of remaining individuals as compared to the stocked level was transformed through arcsine(square root). A t-test was then used to assess if survivorship was affected by the initial presence of the mite parasite. A 2-way chi-squared analysis was used to determine if the initial stocking of infected grasshoppers significantly resulted in different levels of infection by the end of the trial.

Results

The dominant species collected during the grasshopper survey was *M. dawsoni* (75%) followed by *C. pellucida* (17%) and *M. borealis* (7%). One individual grasshopper each of *M. bivittatus* and *C. curtipennis* was collected as well (Figure 1). A large majority of the *M. dawsoni* collected were early (2^{nd}-3^{rd}) instars. Mite infestation for *M. dawsoni* was consistent across developmental stages with overall prevalence at 21% ± 5.3% (Figure 2). The mite prevalence differed across grasshopper species (f value=4.164; df=4,15; p=0.0183). *C. pellucida* had no infected individuals while *M. borealis* had an infection rate of 62%±18.2% (Figure 3).

The rate of survivorship for the grasshoppers in the field enclosures was similar over the 10 day trial despite initial treatment conditions of mites present or absent (Figure 4). At the end of the trial, a final count revealed no significant difference in the overall survivorship (t = 0.2838, df = 7.993, p= 0.7838). As the experiment progressed, the uninfected grasshoppers became infected as well, with the final count resulting in no significant difference in mite infestation levels (X^2 = 2.5175, df = 1, p= 0.1126).

Discussion

The survey strongly suggests that *M. dawsoni* is the dominate species (75% of sampled grasshoppers) in the field site. Additionally, the mites seem to have a host preference for grasshoppers in the subfamily Malanoplinae over grasshoppers from the subfamilies Gomphocerinae and Oedipodinae. For instance, the second most common grasshopper at this site, *C. pellucida* from the subfamily Oedipodinae, was never found to be infected with mites. The field experiment suggests that mites do not significantly impact survivorship of *M. dawsoni*. Both treatment groups had similar survival rates over time.

Although the field experiment used grasshoppers that were initially distinct in the presence or absence of mites, by the end of the experiment both treatments were not significantly different in mite abundance. A potential consequence of this could be why the final survivorship was not significantly different between the two treatment groups. Additionally, most of the grasshoppers were lightly infected (1 or 2 mites), which could explain why there was not a significant difference observed in survivorship. In one enclosure, a cadaver was found infected with *Entomophaga grylli*, a pathogen that can increase mortality rates in early instars (Kistner and Belovsky, 2014). *E. grylli* could have been present in multiple enclosures as well, presenting a potential confounding mortality source. Finally, the relatively short trial of 10 days does not encompass the full life history of *M. dawsoni*. In another study, mites were found to reduce both the survivorship and reproductive capabilities of *M. sanguinipes* (Branson, 2003).

My initial hypothesis of the existence of a single dominant species with a population reservoir of infected individuals was supported by the survey data. However, due to the narrow temporal view of the survey, there is the possibility that a flux in the makeup of the population would occur. The survey methodology was limited by the use of pseudo replication through the use of different time points as replicates. This limited the surveying power, particularly with respect to analyzing the three less common species, *M. borealis*, *M. bivittatus*, and *C. curtipennis*. Additionally, due to the timing of the survey many of the grasshoppers were mainly present in early instar stages Knowledge of the dominant grasshopper species and native parasites could be an avenue for potential pest management applications. Increasing the abundance of mites, for example, could selectively impact the more vulnerable *Melanoplus* genus in comparison to *Camnulla*.

My field experiment, however, did not support my hypothesis of the introduction of mites impacting survivorship However, my study did suggest that mites can quickly spreading throughout a population, as both of my treatments were indistinguishable by the end of the 10 day trial with regards to mite infestation. Future studies in the feasibility and effectiveness of mite application will be needed to investigate this form of bio control.

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Figures

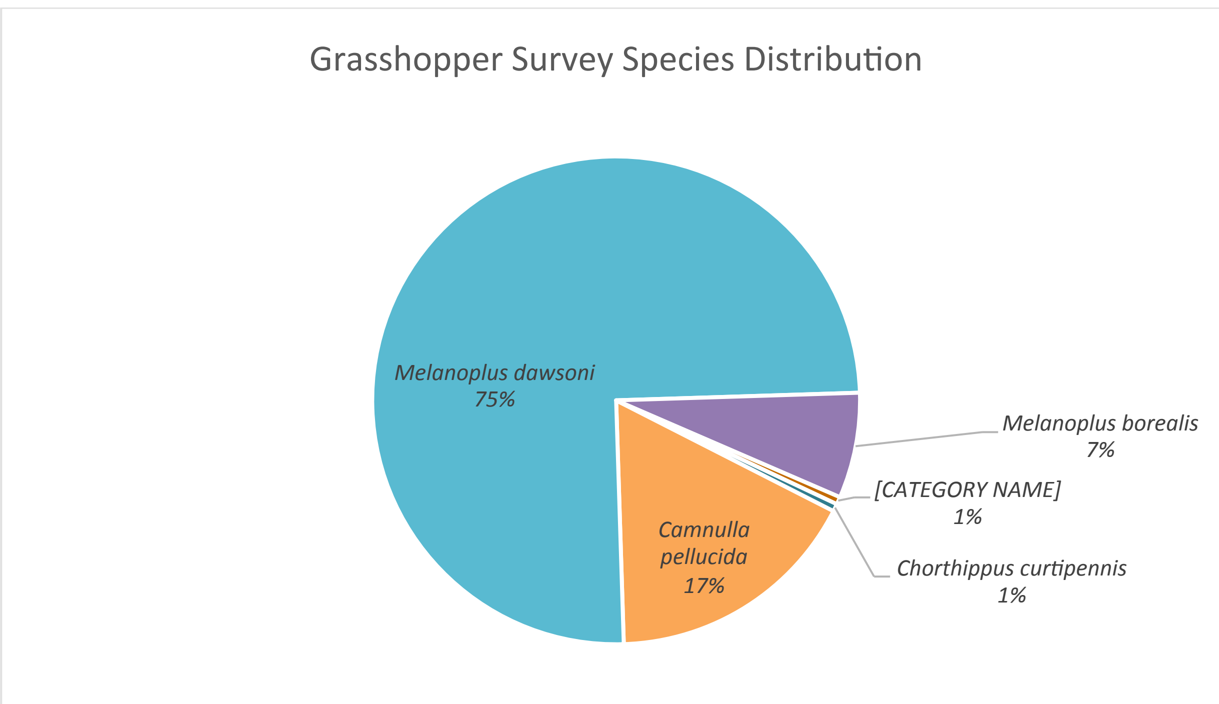

Figure 1. Species distribution of grasshoppers

Over a course of 3 weeks, a total of 200 grasshoppers were collected at Grasshopper Nation. The *M. dawsoni* were the most abundant species with *C. pellucida* also present as an important minority.

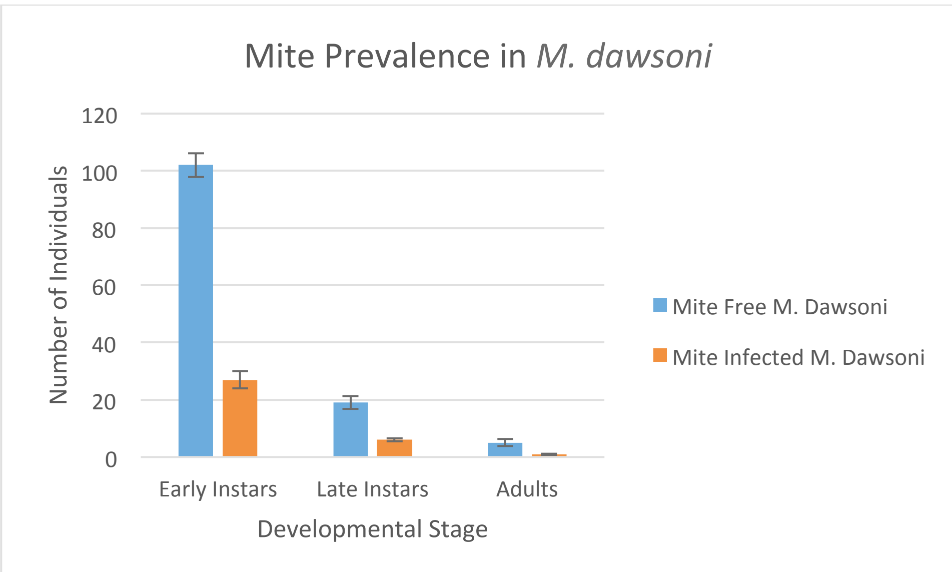

Figure 2. Number of *M. dawsoni* individuals collected

During the 200 grasshopper survey, a large majority of the *M. dawsoni* found were early (2^{nd}-3^{rd}) instars. Vulnerability to mite infestation was present across all developmental stages.

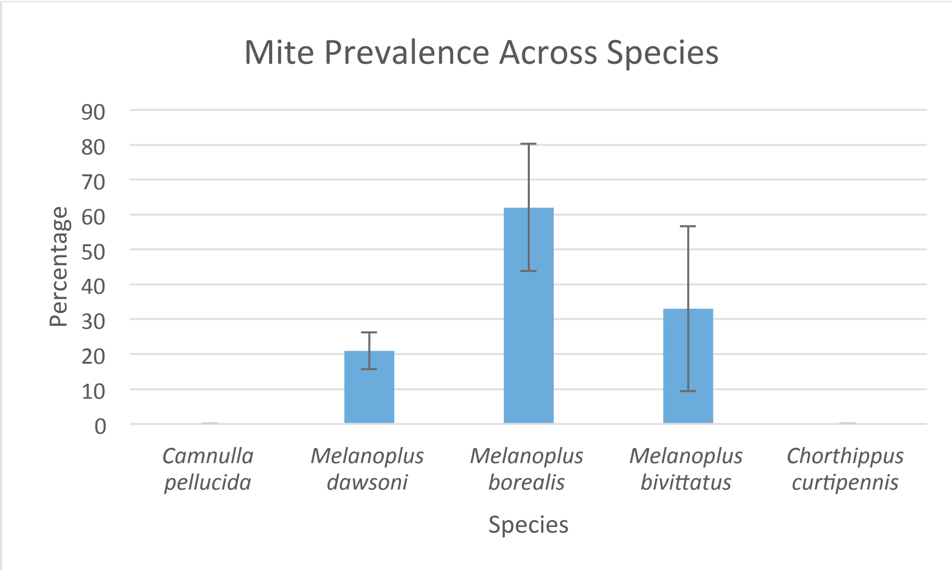

Figure 3. Vulnerability to mite infestation across five species

At Grasshopper Nation, only grasshoppers in the genus *Melanoplus* were found to be infected with mites during the three week period. The highest infection rate was found in *M. borealis* at 62%±18.2%.

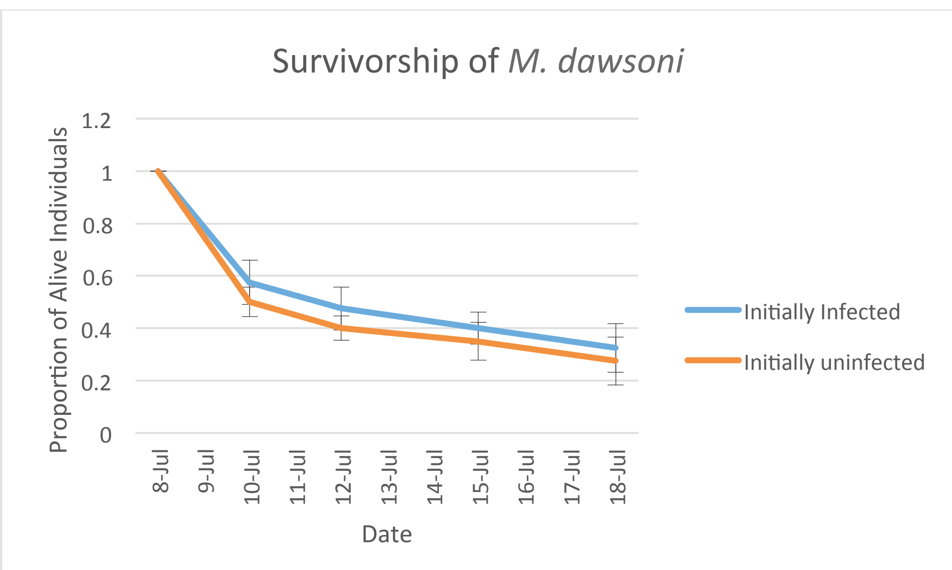

Figure 4. Proportion of remaining grasshoppers in field enclosures over time

The rates of survivorship did not vary significantly between the two groups during a ten day period.