A Study of the Factors Influencing Infection by Sporisorium ellisii in a Population of Andropogon virginicus

Sean Halloran, Dr. Janet Morrison

The College of New Jersey, Ewing, NJ

Abstract

Andropogon virginicus is a common early successional grass that is susceptible to infection by the smut fungus *Sporisorium ellisii*. This relationship is interesting from an evolutionary perspective because the fungus replaces an infected culm's seed, producing spikelets with fungal sori, effectively sterilizing the infected culm and reducing plant fitness. Previous work also shows that the severity of infection correlates with differences in plant morphology, with systemically infected and uninfected plants having fewer tillers on average than partially infected plants. The fungus is fed upon by a mycophagous beetle that lays its eggs in the sori. This beetle may serve as a fungal spore vector thus adding a new dynamic to the plant-pathogen relationship. This study examined fungal infection in relation to plant characteristics and beetle presence. Study of a field site showed a 15% infection rate, with 70% of infected plants harboring the beetle. A second examination of the site a year later showed a 13% infection rate, with 76% of infected plants harboring the beetle. Beetle larvae from infected stalks were collected, raised to adulthood and identified as belonging in the family Anthribidae. Based on these results, a field experiment was designed to exclude the beetle from uninfected plants, with cages and insecticide, in order to determine if beetle presence influenced infection rate. However, only one plant became infected, indicating that the time period of the experiment, June-October, is probably not when initial infections establish in this plant-pathogen system.

Introduction

Plant-pathogen interactions, including those of fungal pathogens, can be influenced by a number of different factors. The means by which the fungus is spread, its effect on the fitness of the host, and the optimal environment of both host plant and pathogen all influence how successfully the pathogen infects new populations.

Fungal pathogens can have significant effects on a host population, which indicates a need for examination of how the pathogen colonizes and spreads in host populations. Fungal pathogens can spread between hosts and populations in a variety of ways. Spores commonly are dispersed by wind; however, organismal vectors can also contribute heavily to the spread of fungal spores. Fungivorous organisms may either control or lower the frequency of disease, or promote further spread of infection within a population. Mycophagous insects in particular can act as vectors for a fungus by carrying spores on their bodies as they migrate between plants.

This may be the case with a beetle that appears to feed off of the spores of the smut fungus *Sporisorium ellisii*. In turn this smut infects a common C_4 early successional grass, *Andropogon virginicus,* sterilizing the grass and replacing its reproductive structures with spore-filled fungal sori. Determining whether this beetle helps spread the fungus between host plants was one aim of this study.

The beetle larva is only found in plants that are infected with the smut fungus. It is possible that after consuming smut spores as larvae, the adults carry other spores on the exoskeleton to new plants as it migrates.

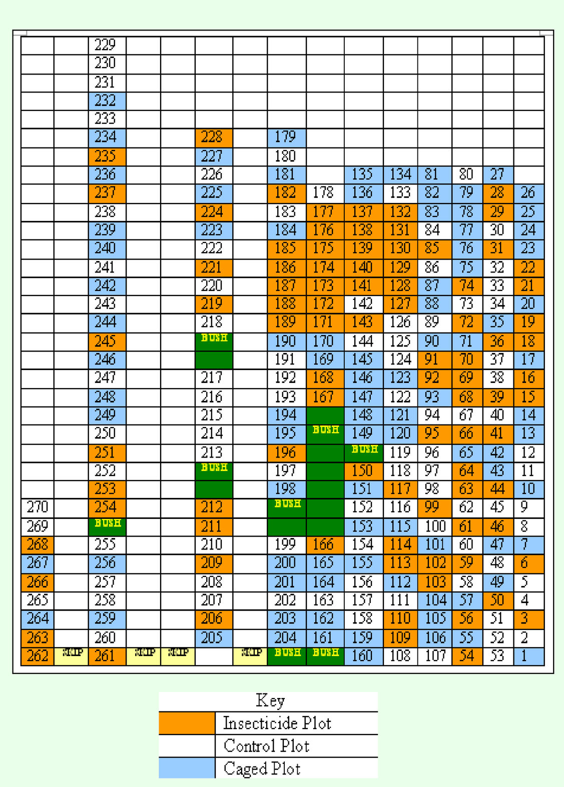
Over the course of the study, a number of tests were run pertaining to the interactions between *A. virginicus*, *S. ellisii*, and the beetle. A field test was designed in order to determine whether beetle presence or absence had any effect on the spread of *S. ellisii*. Larvae were collected also in order to raise and identify the beetle and learn more about its life-cycle. Finally, the field site chosen for the experiment was characterized during the winters of 2004 and 2005 in order to record the infection rate of the smut and the prevalence of the beetle.

Methods

Natural infection patterns. Characterization of the study site was carried out twice over the course of the study in order to determine changes in the infection rate within the site. The first time was from April-May of 2004 while the second was carried out during March 2005. Due to the clustered nature in which *Andropogon virginicus* grew at the study site, characterization of the site was done by laying down modified transects. Five transects separated by five meters each were made, and every meter along each transect the nearest *A. virginicus* plant was located, numbered, and examined. For each plant the number of healthy and smut infected stalks were counted and the height of the tallest stalk was recorded. Additionally, in plants that had stalks containing smut infection, five infected sori were examined in order to determine the presence or absence of beetle larva.

Beetle identification. During the winter 2004 period roughly 50-60 infected sori were collected from the field site and brought back to the lab for examination. Nine beetle larva were located and raised in Petri dishes with smut spores readily available. In late April to early May four of these eclosed as full grown adults which were then identified as being from the family Anthribidae otherwise known as the "fungus-weevils".

Field experiment. A field experiment was designed to determine the insect's role as a vector. *A. virginicus* seeds were collected from the study site during the winter of 2004 and were germinated in a greenhouse. During the summer of 2004 eleven transects separated by 1.5 meters each were laid out over the study site and every 1.5 meters up the transect a greenhouse plant was placed (270 plants total) and one of three treatments was applied. These treatments consisted of either a cage made of an insect-blocking fabric, weekly spraying by an insecticide, or a control treatment where the plants were left alone. Once every three days the site was examined in order to maintain the cages and water the plants if no rain had occurred. In late October 2004, all the plants were recovered and returned to the greenhouse where they were examined for number of healthy and smut infected stalks and presence or absence of the beetle larva.



Above: Cages were covered in a fabric designed to stop insects from reaching the plant, but let spores, water, and sunlight through to the study plants.

Left: Map of the transects set up in the study site during the field experiment.

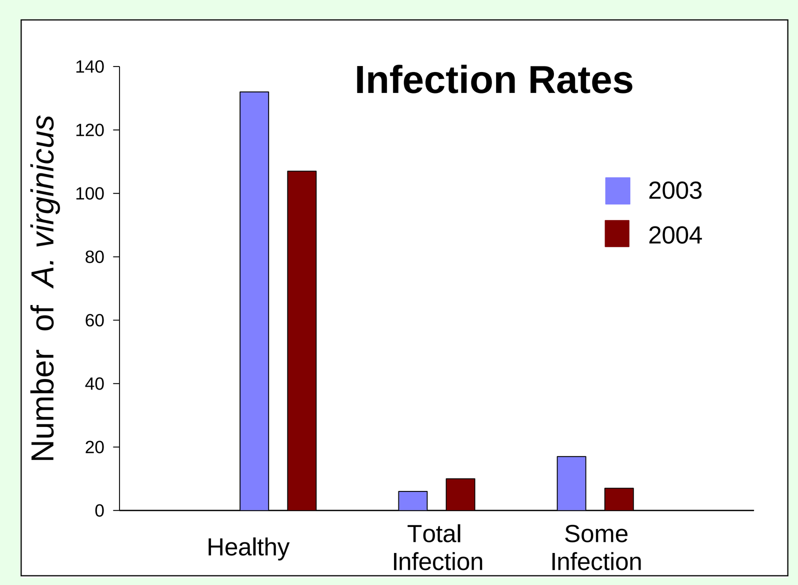
Left, Middle: Beetle larva over-winter inside infected sori and were observed eating spores.

Right: As an adult the beetle is around 1.5 millimeters in length and belongs to the family Anthribidae. The beetle may be mycophagous in its adult form, however, its exact behavior in the field has not yet been observed.

Top: *Andropogon virginicus* plants infected with the smut fungus can be recognized by black spores and sori where reproductive spikelets would usually be.

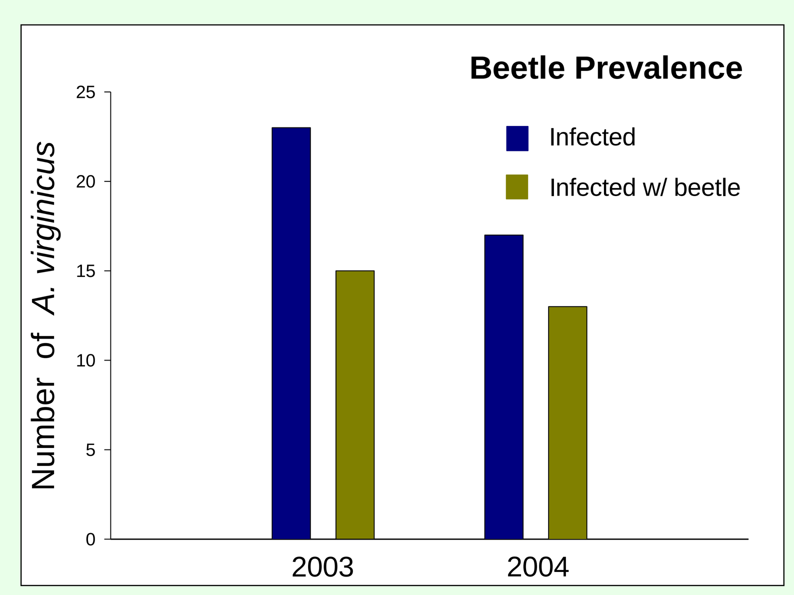
Bottom: In contrast to infected plants, healthy plants usually have an abundance of tufted seeds sticking out of their spikelets.

Results

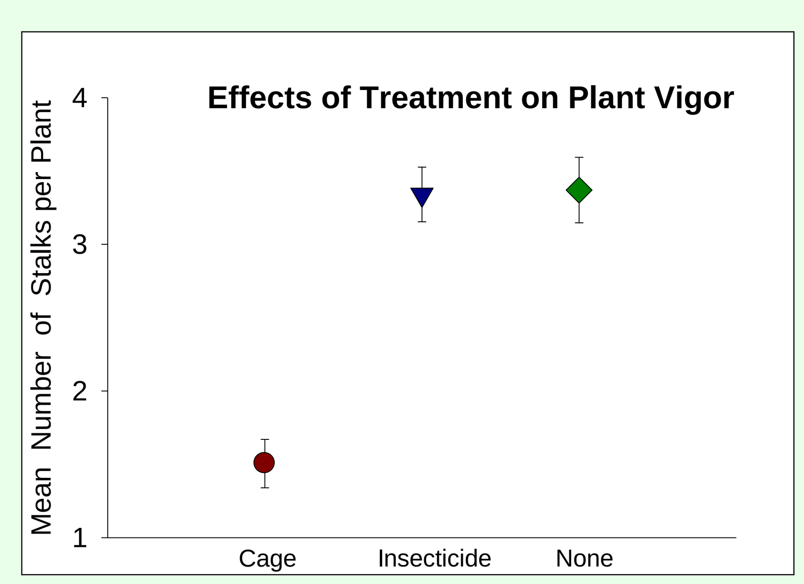


Over the course of two years the percent of plants infected within the site decreased from 14.8% to 13.7%.

Between 2003 and 2004 the percent of infected plants with total infection increased from 22% to 59% while plants with only partial infection decreased from 88% to 41%.



Between the two years it appears as if the prevalence of beetles increased over time, with 65% of infected stalks having the beetle present in 2003, and 76% in 2004. Despite the decrease in overall infection at the site it still appears as if the beetle is able to subsist on this level of infection.



The mean number of stalks on experimental plants was significantly lower ($p<0.001$) in plants that underwent the cage treatment than the plants that underwent the insecticide and control treatments. This indicates that plant vigor may have been negatively affected by the cages ($P<0.001$).

Discussion

Infection rates of this sterilizing smut fungus in the study population of *Andropogon virginicus* were about 14% over the two years, and the intensity of infection in plants that already had the pathogen increased. These results indicate that, indeed, the pathogen has the potential to have serious effects in the host plant population.

The Anthribid beetle's role in the interaction remains unclear. Our study showed that it consumes smut spores as a larva and thus could decrease frequency or severity of infection via mycophagy. There was a slight decrease in the percent of infected plants in the study suggesting that infection was not propagating to new individuals, but rather intensifying within already infected individuals. Alternatively, the beetles may promote the spread of the disease by acting as a vector in the adult stage. The field experiment was unable to show whether exclusion of the beetle also prevented new infections since of 270 study plants undergoing one of three treatments, only a single one showed signs of smut infection.

The smut fungus did not infect its host between the months of June to October when the field experiment was run. In hindsight this makes sense considering that during the summer the field site was rather hot and dry, and perhaps too hostile for the fungal spores. It is also possible that the lack of infection in the experiment simply reflected the fact that infection rate did not increase in the natural population either.

Despite the apparently decreasing levels of infection within the site, it appeared that the beetle population was not at all negatively affected. Between 2003 and 2004 the percent of infected plants that also carried the beetle larvae increased from 65% to 75%. However, whether or not this demonstrates an actual increase is not completely certain. Over the course of the study more experience was gained in locating beetle larva and therefore it is likely that at least some portion of the increase between years can be attributed to these more refined skills. In any case, beetle prevalence in the site remained high despite the overall decrease of infection.

Future studies into the interactions between *A. virginicus* and *S. ellisii* should involve a field experiment where the study plants are placed into the field year-round in order to catch the window of time when new plants become infected and when beetles first begin emerging. The cages used in this study also must undergo some changes before being used again since caged plants were smaller.

Acknowledgements

Thanks to Dr. Janet Morrison for helping to design and set up the experiment, as well as for help in analyzing the results.

Thanks to Dr. Dennis Shevlin for assistance in assessing spore viability.

Thanks to Dr. John Lawrence for his invaluable assistance in identifying the beetle to family level.

Thanks to Brian Dunn, Kelly Marie McCartney, and Rob Kral for help in setting up the field experiment.

Thanks to Kerry Mauck for help in photographing the smut fungus, beetle, and larvae, as well as setting up the experiment and assisting in data collection.