The role of plant competition and natural enemy attack in forest seedling success

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Abstract: While there are an increasing number of studies being done on the competitive relationship between native and non-native plant species, there are relatively few that compare the ecology of co-occurring non-native species. We compared three important co-occurring non-native invasive species, *Acer platanoides* (Aceraceae) also known as Norway maple (a shade tolerant tree), *Microstegium vimineum* (Poaceae) or Japanese stilt grass (a woodland grass) and *Alliaria petiolata* (Brassicaceae) or garlic mustard (a dicot herb). Seedlings of all three were planted experimentally in three different forests in central New Jersey and followed for mortality and natural enemy attack when grown with and without competitors. All three species exhibited considerable enemy damage, which does not follow the expected pattern of the Enemy Release Hypothesis (ERH), which suggests that non-native are expected to experience similar and relatively small amounts of damage from disease and herbivory. The results show that the species differed in percent leaf area with insect damage (means -- garlic mustard 18.15%, stilt grass 8.19%, Norway maple 15.96%). They also differed in percent leaf area with disease symptoms, which itself was influenced by competition (with competition; means -- garlic mustard 6.16%, stilt grass 9.06%, Norway maple 2.87%; without competition; means -- garlic mustard 1.07%, stilt grass MV 8.26%, Norway maple 7.82%). Also, the species differed in mortality rate by the end of the season (P = 0.0004; means – garlic mustard 47%, stilt grass 13%, Norway maple 32%). The results from this study suggest that of the three species, stilt grass is most successful in these forests.

Introduction:

An invasive plant species is one that has been transported by humans across major geographical barriers and is able to survive and reproduce so well that it not only becomes established but also overtakes native plant species. The Enemy Release Hypothesis explains that the introduced species has escaped or been "released" from its natural enemies and does not have many enemies (whether herbivores or disease) in its new habitat. The native species, however are still susceptible to these attacks, but also have to compete with the exotic species.

These invasions are mainly caused by human interaction, whether accidental or planned. It is important to understand why these plants become invasive and the effects they have on the native flora because 50-80% of invaders have harmful effects on the original ecosystem. For example, biological invasions cause more extinctions of native species than climate and atmospheric changes together and is probably only second to changes caused by humans' land use.

Plants respond differently to different living conditions. Differences in the soil nutrients, sunlight, and plant densities all effect growth. Successful plants respond to these differences by adapting their growth and distributing biomass to different structures. These adaptations should maximize growth rates and allow for obtaining the highest quantity of resources from the environment. For example, in poor soil, a plant may focus its energies more on producing a root system that may reach to better soil, than on producing leaves. Alternately, if a plant is being shaded by nearby plants, it may put more energy into making a larger stem to help it rise above its neighbors, or develop more chloroplasts. Perennials tend to put more energy into their root system than annuals because they will not need to survive through the winter, while annuals place more emphasis on reproduction.

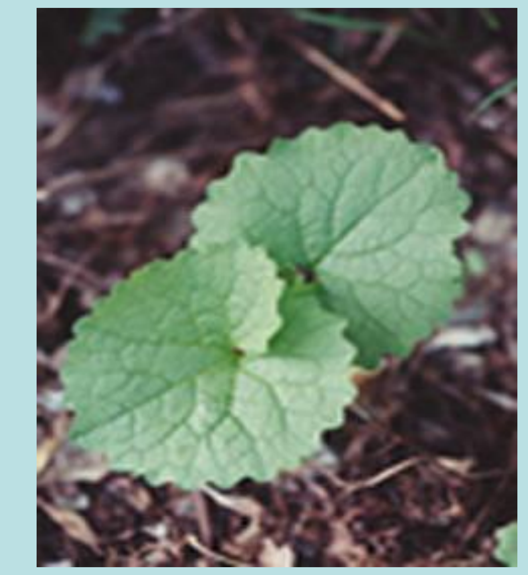
In this study, three co-occurring invasive plant species with different life history strategies were compared for herbivory, disease, and juvenile mortality. Norway maple (NM) or *Acer platanoides* (Aceraceae) is a shade tolerant tree native to Europe. Japanese stilt grass, *Microstegium vimineum* (MV) (Poaceae) is a woodland grass. Garlic mustard (GM), *Alliaria petiolata* (Brassicaceae) is a non-native dicot herb. Few studies have compared co-occurring invasive plants species; many more have been done to test the relationship between invasive and native species. However, it is important to understand the relationship between the increasingly dominant invasive species to understand the changes that may be occurring in our forests. We expected our results to comply with the Enemy Release Hypothesis, however, if the results stray from the ERH, then it may be possible to use the competition between the species as population control between invasives.

Methods:

This experimental study was part of a larger study that also compared the relationship between native and invasive species. Three forests (blocks) were used to test the hypothesis. These forests are on land that is typical for central New Jersey. Five replicates of each treatment combination were established in each forest. Focal seedlings of each species (garlic mustard (GM), Norway maple (NM), *Microstegium vimineum* (MV)) were grown alone or in competition with two seedlings of another invasive plant species in the study (variable), and then these were subjected to one of five different treatments: open (completely exposed to the elements), insecticide (preventing insect herbivory), mammal cages (preventing larger animal herbivory), and fungicide (protected from disease). Focal plants were evaluated for survival, disease symptoms, and herbivory symptoms. Because of damage caused by the chemical treatments, those plots were excluded from the analysis here.

Norway maple

Japanese stilt grass



Garlic Mustard

Results:

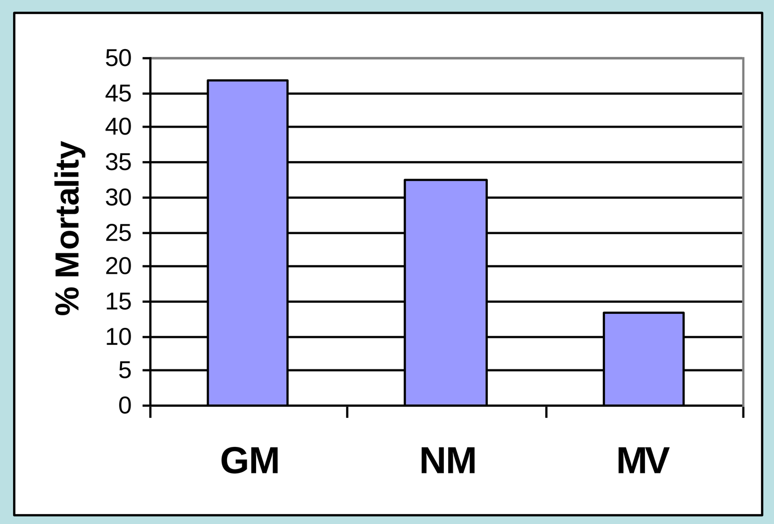


Figure 1. GM experienced the highest mortality rate, while MV experienced the lowest mortality rate. (G=16.69, df=2, P=0.0002)

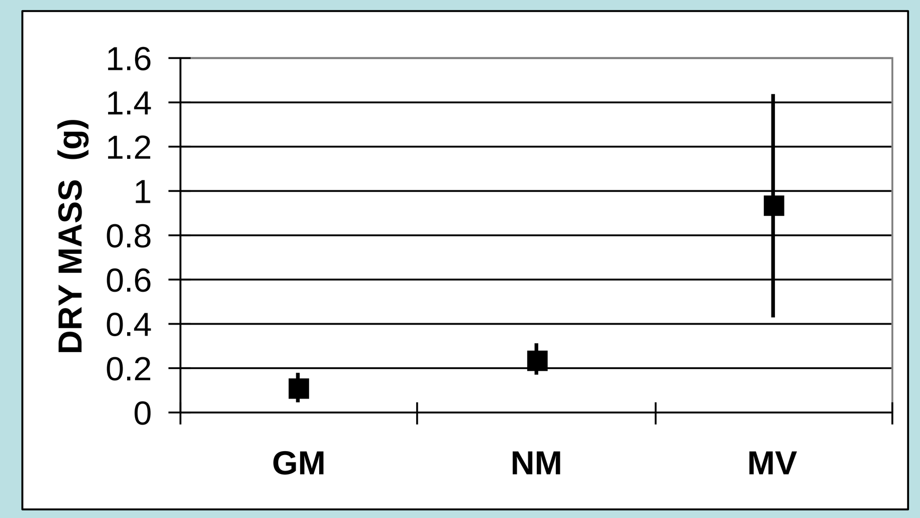


Figure2. The dry mass for the MV shows that it spent a lot of energy making biomass in its stems and leaves in comparison to GM and NM. ($F_{2,71}$= 13.26, P<0.0001)

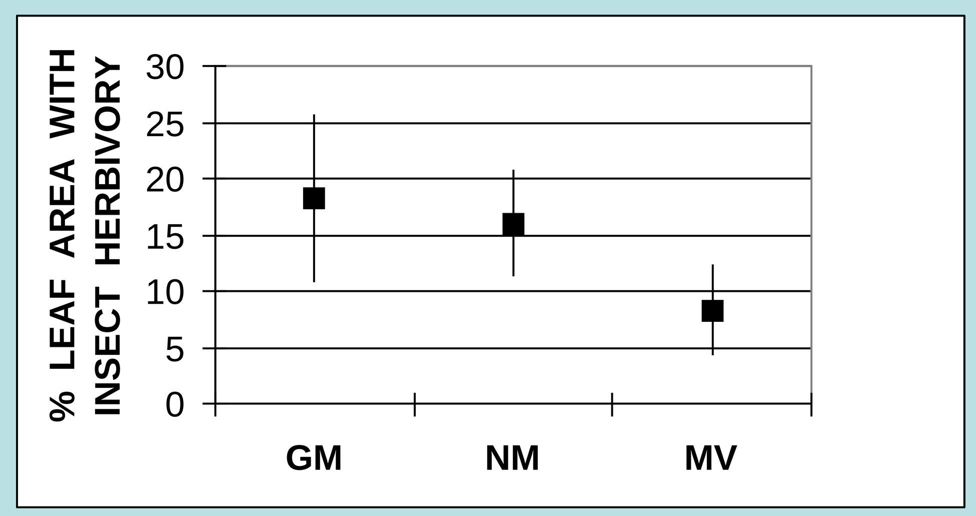
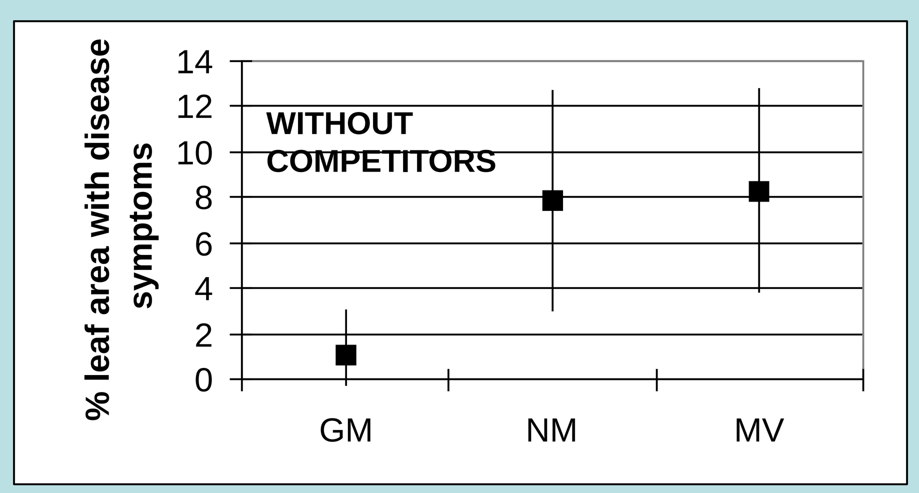


Figure3. GM and NM both experienced a larger amount of herbivory than the MV ($F_{2,71}$= 2.80, df= 2, P<0.0640)



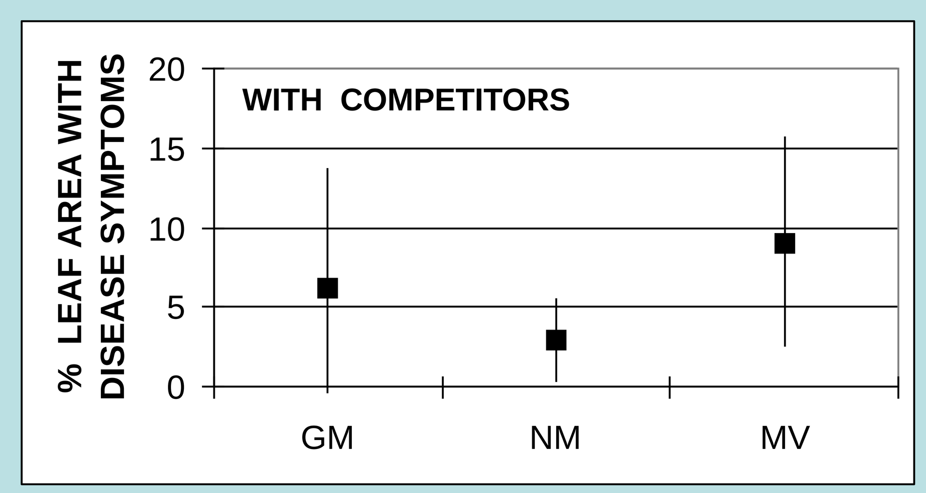


Figure 4 and 5. There is a difference in the amount of disease symptoms found in the focal species with and without competition. Under competition, disease increased most for GM and MV. NM, however, experienced a decrease in disease symptoms when competition was added. ($F_{2,71}$= 3.40, df= 2,P<0.0360)

Discussion:

The study did not follow the prediction of the Enemy Release Hypothesis that invasive species have escaped their natural enemies. All three of the non-native invasive species in our experiment experienced substantial herbivory and disease symptoms.

Garlic mustard and Norway maple both experienced a larger amount of herbivory than Japanese stilt grass, which may have some sort of defense against insect herbivores. This may be one of the reasons that stilt grass experienced the lowest mortality rate (while garlic mustard experienced the highest mortality rate).

Disease symptoms on the focal plants were affected by the presence of competitors, but not in the same way for all species. The marked increase in symptoms on garlic mustard in the plots with competitors present was not seen for stilt grass and was the exact opposite for Norway maple. Clearly, plant characteristics other than native status influence the outcome of plant-plant-enemy interactions in the forest setting.

Stilt grass seems to be best adapted overall to its new habitat; it had lowest mortality, lowest herbivory, and highest biomass. The only category where it fared worse was for disease symptoms, but this did not appear to negatively affect either survival or growth. In addition, its root to shoot ratio shows that stilt grass allocated most of its biomass to stems and leaves. This would benefit it most, since this grass only lives for one season. Its first priority is to grow and reproduce. To ensure its survival, it quickly grows tall stems and a lot of leaves to ensure it is not shaded out by other plant species. The Norway maple (tree) and the garlic mustard (biennial) allocate more biomass and resources to their roots to ensure they will survive the winter.

Though each of the three species studied were invasive, they each used different methods to survive. Stilt grass seems to be out competing the Norway maple and the garlic mustard, at least in their first season. Though stilt grass is a cause of problems for native forests, perhaps it can be used to control other invasive species, like Norway maple and garlic mustard.