Summer 2007

The effect of the invasive garlic mustard (Alliaria petiolata) on levels of herbivory in white oak and sugar maple seedlings

Ellen Thompson

The effect of the invasive garlic mustard (*Alliaria petiolata*) on levels of herbivory in white oak and sugar maple seedlings

Ellen Thompson '08 and Andrew Kerkhoff, Department of Biology, Kenyon College, Gambier, Ohio

Overview

Alliaria petiolata has been found to disrupt trees' associations with arbuscular mycorrhizal fungi. This study investigated the effect of *Alliaria* and fertilizer treatments on levels of insect herbivory in white oak and sugar maple seedlings. Proportion of leaves damaged on seedlings grown in the presence and absence of *Alliaria* and fertilizer was measured throughout the summer. Maples experienced greater herbivore damage than oaks. Maples grown in the *Alliaria*-free treatment were more damaged than those grown in the presence of *Alliaria.* This suggests that having intact arbuscular mycorrhizal fungi associations allows a plant better nutrient uptake, making it more attractive to herbivores.

Background

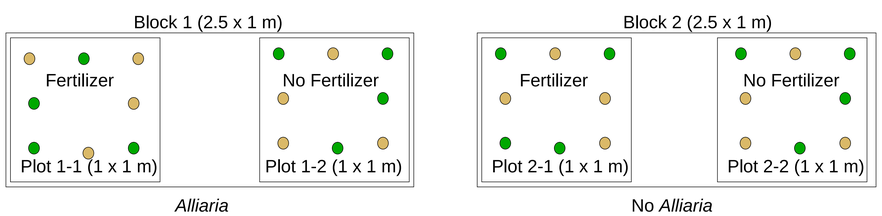
***Alliaria*:** *Alliaria* is one of the top ten invasive plants of concern in Ohio. It has been found to disrupt trees' associations with arbuscular mycorrhizal fungi (AMF) which colonize plant roots and help the plant with nutrient uptake in exchange for photosynthetically fixed carbon (Stinson et al. 2006).

Herbivory: Decreased AMF associations due to *Alliaria* could cause:
- Greater levels of herbivory if decreased AMF associations lead to a lower concentration of carbon-based defensive compounds (Gange and West 1994).
- Lower levels of herbivory if plants have a lower nutrient content and thus are less attractive to herbivores due to fewer AMF associations (Jansson et al 1991; Schade et al. 2003).

Seedling Species:
- Sugar maples have AMF so it is expected that they will respond to *Alliaria* treatments.
- White oaks may be unaffected by *Alliaria* presence because they are ectomycorrhizal and there have been no documented effects of *Alliaria* on ectomycorrhizal associations.

Methods

Experimental setup:
- Research was conducted in a 1 ha study plot near the Bishop's Backbone trail on property owned by the Brown Family Environmental Center at Kenyon College.
- White oak and sugar maple seedlings were planted at ten evenly spaced study sites within the ha in late April. A study site was set up as follows with four seedlings of each species randomly planted in each plot:



Treatments:
Alliaria: one block of each site was weeded and maintained *Alliaria*-free
Fertilizer: time release (2 yr) fertilizer tablets were inserted in the soil adjacent to each seedling in one plot at each block.

Data Collection:
- The proportion of leaves damaged (number of leaves showing herbivore damage/total number of leaves on seedling) on one seedling of each species in each plot at the 10 study sites was counted three times throughout the summer.
- An assay was conducted to determine the relationship between proportion of leaves damaged on a seedling to the proportion of leaf surface area damaged at an additional site with 70 seedlings/plot.
  - Once a week for six weeks, five seedlings of each species in each plot were selected for sampling. The proportion of leaves damaged on each seedling was counted. Three leaves from each seedling were collected and analyzed for percent leaf area damaged using ImageJ software.

Results

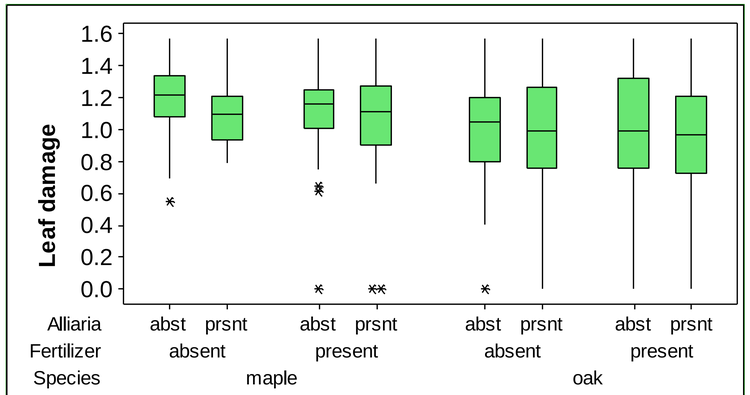


Figure 1. Mean leaf damage across all treatment and species of seedling combinations. Leaf damage was quantified by taking the arcsin of the square root of the proportion of leaves damaged on each seedling.

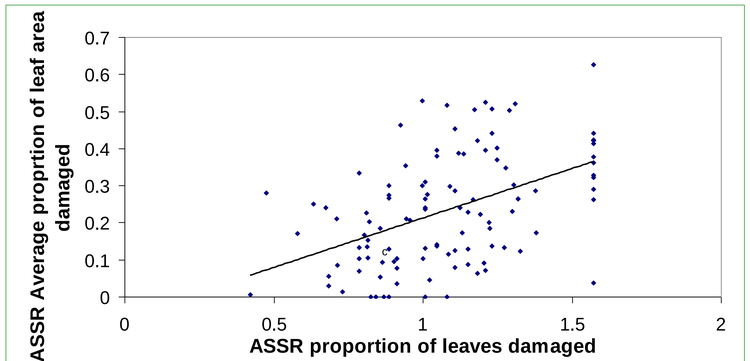


Figure 2. The relationship between the average proportion of the leaf area damaged and the total proportion of leaves damaged on both white oak and sugar maple seedlings. The arcsin of the square root of both proportion and percent data is displayed. R^2=.209. Pearson correlation $p<0.05$.

Summary

Species response: Maples experienced greater herbivore damage than oaks ($p<0.05$). Oaks produce tannins which are known to be strong defensive compounds, so they may be better protected from herbivory than maples. Maples seem to be more affected by the presence of *Alliaria* which is also expected because oaks are ectomycorrhizal, and so their mycorrhizal associations are not affected by *Alliaria* presence.

***Alliaria* effects:** Maples were less damaged in plots with *Alliaria* ($p=0.087$). AMF likely play a larger role in nutrient uptake rather than the production of defensive compounds since herbivore damage was greater on maple seedlings in the absence of *Alliaria.* This increased nutrient uptake due to intact AMF associations in the absence of *Alliaria* makes the plants more attractive to herbivores, thus herbivore damage is greater.

Proportion of leaves damaged-leaf area damaged relationship: The proportion of leaf area damaged was correlated to the proportion of leaves damaged on the seedling. This gives confidence in the use of proportion of leaves damaged as a measure of total herbivory on the seedling.

Future Work

- Nutrient analysis of collected leaf samples to determine the relationship between *Alliaria*, leaf nutrient content, and level of herbivory.
- Mycorrhizal assays of seedlings to ascertain whether *Alliaria* is disrupting mycorrhizal associations.
- Continued data collection as this was the first year of a larger study.

Acknowledgments

I would like to thank Professor Andrew Kerkhoff for his guidance on this project. In addition, Kaleb Keyserling and Amy Kessler assisted in data collection and provided entertainment and support throughout the course of this project. Funding was provided by the Kenyon Summer Science program.

References

Gange, A. C. and H. M. West. 1994. Interactions between arbuscular mycorrhizal fungi and foliar-feeding insects in *Plantago lanceolata* L. *New Phytol.* 128: 79-87.
Jansson, R. K., G. L. Leibee, C. A. Sanchez, S. H. Lecrone. 1991. Effects of nitrogen and foliar biomass on population parameters of cabbage insects. *Entomologia experimentalis et applicata* 61: 7-16.
Schade, J. D., M. Kyle, S. E. Hobbie, W. F. Fagan, and J. J. Elser. 2003. Stoichiometric tracking of soil nutrients by a desert insect herbivore. *Ecology Letters* 6: 96-101.
Stinson, K. A., S. A. Campbell, J. R. Powell, B. E. Wolfe, R. M. Callaway, G. C. Thelen, S. G. Hallett, D. Prati, and J. N. Klironomos. 2006. Invasive plant suppresses the growth of native tree seedlings by disrupting belowground mutualisms. *PLoS Biology* 4: 727-731.