Two invaders in the same forest: light use and competition comparisons

Heather McMahon and Janet Morrison, Department of Biology, The College of New Jersey

Abstract. The biennial herb *Alliaria petiolata* (garlic mustard) and the annual grass *Microstegium vimineum* (Japanese stilt-grass) are two non-native plant species that spread into forests in the eastern U.S.A. Both grow in a wide range of light environments and colonize together in mixed stands. Study plots with both species present were found at Washington Crossing State Park in New Jersey. Light levels, percent cover, and photosynthesis rates were measured in each plot for each species. Cover of *M. vimineum* was greater per plot than cover of *A. petiolata*, and decreased with light level, while *A. petiolata* percent cover was unrelated to light levels. In July and September, *M. vimineum* had greater mean photosynthesis rates than *A. petiolata*. However, *A. petiolata* matched those higher rates during its rapid spring growth, measured in April before *M. vimineum* had germinated. In a greenhouse experiment, *M. vimineum* exhibited higher photosynthesis rates, as well as the ability to increase photosynthesis at a greater rate when exposed to increased light levels, suggesting that it may have an advantage over *A. petiolata* in the forest by more readily utilizing high light patches. However, in greenhouse competition with a native species, *A. petiolata* had greater overall mass than *M. vimineum* due to root growth, in both light and shaded treatments. The two species appear to utilize different strategies to promote invasion. Understanding how co-occurring non-native species specifically act within the ecosystem can be helpful for creating management strategies in areas where simultaneous invasions threaten native biodiversity.

Introduction

Two non-native species currently invading New Jersey's forests are the biennial C_3 herb *Alliaria petiolata* (garlic mustard) and the annual C_4 grass *Microstegium vimineum* (Japanese stilt grass). Both species grow in a wide range of light levels, often in mixed stands, and appear to be displacing native plants. Typically, C_4 plants are well adapted to high light environments and can tolerate dryer growing conditions. Conversely, C_3 plants are limited by stomatal closure and may do better in cooler, shaded environments. Despite these theoretical limitations, both *A. petiolata* and *M. vimineum* grow together in a wide range of light environments. The purpose of this investigation was to understand how each species utilizes available light throughout the growing season to promote invasion and competition against native plants, with the ultimate goal of understanding whether one species is likely to be the dominant invader, or whether both species can successfully invade side-by-side. The study had two main components - a field study investigating the relationship between *A. petiolata* and *M. vimineum* density and light levels and how they performed photosynthetically in situ over the course of a growing season, and a greenhouse competition study in which the two species' photosynthesis and competitive ability against a native plant were assessed under different light levels.

Methods

Field Study

- Study site was in mixed deciduous and eastern red cedar forest in Washington Crossing State Park (WCR) in central NJ.
- Seven transects 100 m in length and 15 m apart each with four 1-m^2 plots marked where both invasives co-occurred.
- PAR (photosynthetically active radiation) recorded mid-morning (AM) and mid-afternoon (PM) for each plot (Oct. 2001) with AccuPAR.
- Percent cover of each species estimated (Nov. 2001).
- Photosynthesis rates measured on the two largest plants in each plot with Li-Cor 6400 :

  For *A. petiolata*: in April, July, Sept., Nov. 2002

  For *M. vimineum*: in July, Sept. 2002
- Total soil moisture measured from cores for most plots (October 2003)

Greenhouse experiment

- *A. petiolata* and *M. vimineum* seeds collected from light gaps and closed canopy. *Eupatorium rugosum* seeds collected for use as native competitor. All seeds stratified at 5°C in the dark.
- <u>Factorial experimental design – started April 2002</u>

7 blocks with 40 pots/block, allocated randomly into 8 treatments/block :

(*A. petiolata* or *M. vimineum*) **X** (light gap or closed canopy origin) **X** (shaded or unshaded pot)

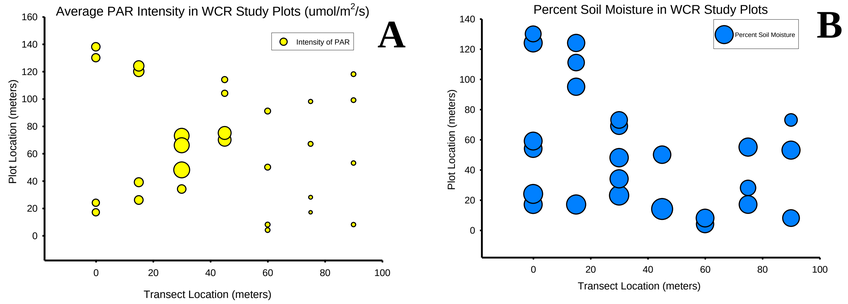
All pots received a non-native seed and a *E. rugosum* seed.

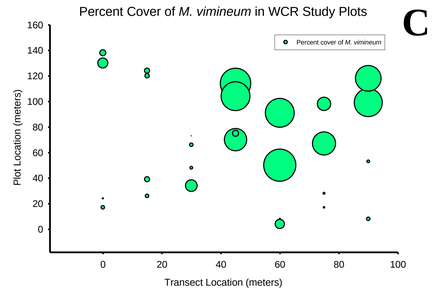
- <u>Data Collection – July 2002</u>

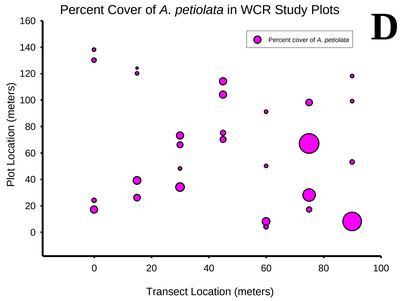
Measured photosynthesis rates at a high (1000 μmol/m^2/s) and low light level (84 μmol/m^2/s) for both species in blocks 1-4.

Harvested both invasive species and the phytometer from all blocks, dried roots and shoots at 60°C to obtain dry mass.

Results: Field Study

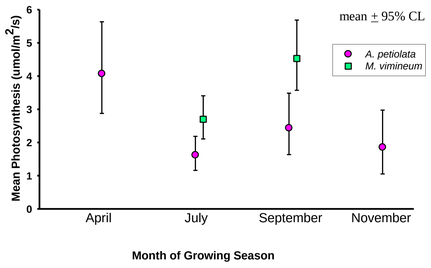




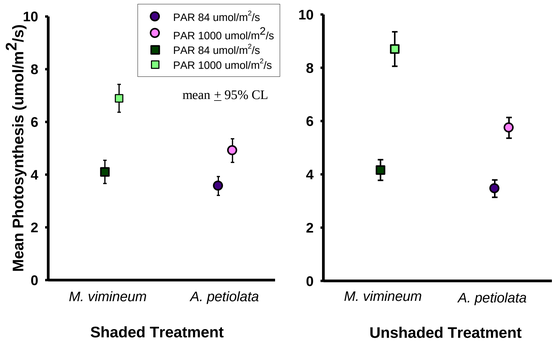


ABOVE: Figure 1A - D. Relative circle size within a graph shows spatial variation of the variable across sampled plots. Percent cover was greater for *M. vimineum* than *A. petiolata* (C and B; paired t-test = 3.81, P<0.001), and decreased slightly with light level for *M. vimineum* (A and C; regression, R^2 = 0.09, P= 0.11). Light varied across the site (A), but soil moisture was similar (B).

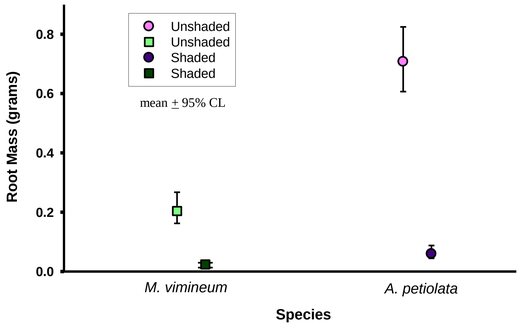
RIGHT: Figure 2. *M. vimineum* photosynthesized at greater rates than *A. petiolata* in the months when both were present (ANOVA, $F_{SPECIES}$=24.45; P<0.0001). April rates for *A. petiolata* were as high as summer rates for *M. vimineum*.



Greenhouse Experiment



ABOVE : Figure 3. *M. vimineum* plants photosynthesized at higher rates than *A. petiolata* and were able to increase their rates to a greater extent when light was increased from 84 µmol/m^2/s to 1000 µmol/m^2/s PAR in the Li-Cor 6400 (ANOVA, $F_{SPECIES \times PAR}$ = 27.35; P<0.025).



ABOVE : Figure 4. *A. petiolata* produced larger mass than *M. vimineum* during competition, due to root growth, in both shaded and unshaded treatments ($F_{SPECIES}$=69.05; P<0.001).

Discussion

Natural areas that are subject to invasion by one non-native plant species are likely to be vulnerable to other invasive species as well, since the conditions that favored one invasive are likely to be the same conditions favoring other weedy species. However, researchers tend to conduct studies on single invasive plant species, without regard to the ecology of co-occurring invasives, which may be important competitors in the system. Management decisions can become complicated by the presence of multiple invasives; it is important, then, to understand the ecology of each so that priority can be given to the more problematic species.

Fragmented forests in New Jersey usually carry multiple invasive loads, and the forest we studied is no exception, with *Alliaria petiolata* and *Microstegium vimineum* the dominant invasives. The combined results of our field and greenhouse study suggest that the two species utilize the forest in different ways, allowing both to be successful.

The biennial *A. petiolata* maximized photosynthesis in spring, before the annual *M. vimineum* had established, then was overtaken in photosynthesis during the hotter summer months by *M. vimineum* with its C4 photosynthesis. The greenhouse experiment indicated that *M. vimineum* leaves also were better able to take advantage of elevated light levels, suggesting that they may be good at utilizing sunflecks within the forest under closed canopy in the summer. By the end of the growing season, percent cover of *M. vimineum* was, in fact, greater on average than that of *A. petiolata* rosettes, but the much greater *A. petiolata* root growth during competition with a native plant in the greenhouse suggests that its belowground biomass in the field was likely greater than that of *M. vimineum*. Neither species showed a strong relationship between plant cover and light in the forest - if anything, *M. vimineum* cover was lower in higher light plots. There are probably other spatial environmental variables that influence the density of these two plants in the forest, but preliminary data do not indicate that soil moisture is important. Future spatial analysis should increase our understanding of the relationships between these two species and underlying environmental variables.