Pollinator-mediated interactions between an invasive shrub, *Lonicera maackii*, and native herbaceous perennials

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Background

- Invasive plants compete with native plants for resources, one of which is pollinator services.
- Invasive plants can interfere with pollinator behavior (frequency and pattern of visits) and reproductive success of co-flowering native plants (e.g. Grabas & Laverty 1999, Chittka & Schürkens 2001, Totland et al 2006).
- Previous work has focused on effects of invasive flowers but has not considered how plant invasions change vegetation structure in ways that may alter pollinator foraging and subsequent reproductive output of co-occurring plants.
- I investigated interactions between an invasive shrub and native herbs to test for effects of both invasive flowers and increased forest understory shade.
- Shrubs increase shade in the understory, and increased shade decreases temperature (e.g. Herrera 1997), which may influence foraging of some pollinator species (Herrera 1995b). Lower light availability in the forest understory directly affects pollinator foraging (Herrera1995a,1997) and may also directly reduce reproductive output of native understory herbs (Fig 1).

Possible interactions between invasive shrub & native herb

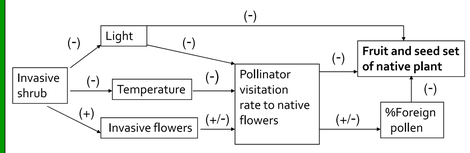


Figure 1. Potential mechanisms of effects of presence of an invasive shrub on reproductive output of a native herb. Signs above arrows represent hypothesized direction of interactions.

Objectives & Hypotheses

Objective: Determine local-scale effects of presence of an invasive shrub on female reproductive success of a.) a native herb flowering after the invasive, b.) a native co-flowering herb and c.) the underlying mechanism of these effects by separating the effects of shade vs. invasive flowers and pollen vs. light limitation of reproduction.

H1 (Pattern): Visitation rate and number of conspecific pollen grains delivered to native stigmas will be lower in the presence of the invasive shrub.

H2 (Pattern): Fruit and seed set will be lower in the presence of invasive shrub.

H3 (Mechanism): Lower fruit and seed set will be due to reduced visitation and conspecific pollen deposition in both herbs; reduced pollination services will be due to both flowers and shade/temperature in the co-flowering species, and flowers will have an additional negative impact on pollinator services compared to shade only.

Reduced pollinator services in the post-flowering herb will be due only to lower shade and/or temperature.

Methods

Study Site

This study was conducted during May 2007 and 2008 in Three Creeks Metropark in Groveport, Ohio, USA in a fragmented forest invaded by *Lonicera maackii*.

Study Species

Lonicera maackii, a native of China, is invasive in forests and fields of the Eastern US (Luken & Theiret, 1996). It produces numerous flowers with nectar and pollen rewards, and both social and solitary bees visit its flowers.

Hydrophyllum macrophyllum is also a perennial herb native to the eastern US and requires pollinators to set seed (Beckman, 1979). It's pollinators overlap with *L. maackii,* but it flowers immediately **following** *L. maackii*.

Geranium maculatum is a facultatively outcrossing perennial herb native to the Eastern US. It's bloom and pollinators **overlap** with that of *L. maackii* (Goodell & McKinney, unpublished data).

Experimental Design

- 36 circular plots with a 10m radius
- 3 Treatments: 1. *L. maackii* removed (no shade, no flowers)
  2. *L. maackii* de-flowered (shade, no flowers)
  3. *L. maackii* intact/flowering (shade, flowers)

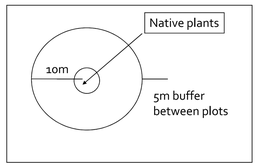


Figure 2. Plot design

Removal plot

I placed four potted plants of each native species in holes in the ground in the center of each plot so that tops of pots were flush with the ground. Pots exclude competition with *L. maackii* for soil nutrients or water and isolate pollinator-mediated effects on reproduction. Two plants per species remained open pollinated in each plot and two were hand pollinated with outcross pollen to test for pollen limitation. I compared reproductive output of supplemental pollinated plants between shade and light treatments to assess light limitation. I built fences around native plants to prevent deer herbivory and watered them as needed.

Results

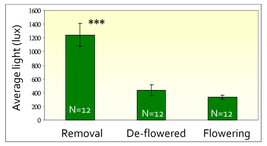
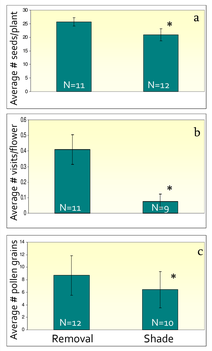


Figure 3. Light was analyzed with a mixed model ANOVA. Plot nested within treatment was a random variable and treatment was a fixed variable. Error bars represent ±1 SE.

- Light was higher ($p<0.0001$), as measured with a light meter, in removal plots (Fig 3). Therefore, light may impact pollinator services and/or plant reproduction.
- Temperature did not differ among treatments (not shown).

Hydrophyllum macrophyllum

Pattern



- Plants under the *L.maackii* canopy produced fewer seeds (Fig 4a; $p=0.025$) than plants in plots with no *L. maackii.*
- There was no difference in fruit set between treatments (not shown; $p=0.546$).
- Plants under the *L.maackii* canopy received fewer visits (Fig 4b; $p=0.014$) and mean rank conspecific pollen grains (Fig 4c; $p=0.041$) than plants in plots with no *L. maackii.*

Figure 4. Removal: *L. maackii* removed. Shade: *L. maackii* intact. Bars are means and error bars represent ±1 SE. Response variables in a-b were analyzed with a mixed model ANOVA; plot nested within treatment was a random variable and treatment was a fixed variable. Graph c was analyzed with a Wilcoxin test.

Mechanism

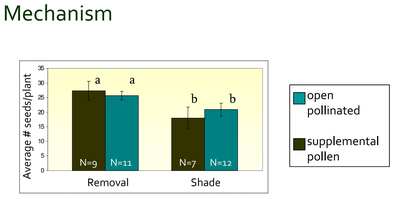


Figure 5. Pollen & light limitation were analyzed with two-sample t-tests. Bars are means and error bars represent ±1 SE.

- Seed set of supplemental pollinated plants was higher in the removal treatment (Fig 5; $p=0.044$), suggesting that light availability limits seed set.
- Seed set was not pollen limited in either treatment (Fig 5).

Geranium maculatum

Pattern

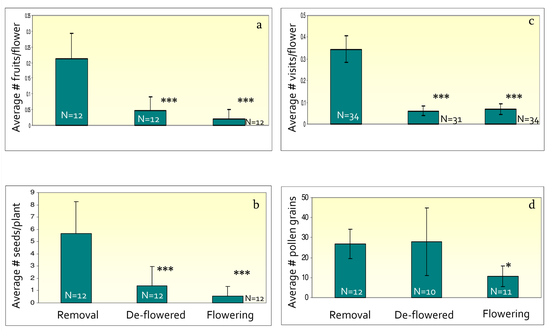


Figure 6. All response variables were analyzed with a nonparametric ANOVA to test for overall differences; planned comparisons were carried out with a Wilcoxin test. Above data in graphs a-c is from 2007-2008 combined, and graph d is from 2007 only. Bars are means and error bars represent +1 SE a-b; ±1 SE c-d.

- Plants in removal plots set fewer mean rank fruits/flower than plants in de-flowered ($p<0.0001$) and flowering ($p<0.0001$) plots (Fig 6a). 58.9% of plants in removal plots produced at least one fruit vs. 17.5% and 6.98% of plants in de-flowered and flowering plots, respectively.
- Plants in removal plots set fewer mean rank seeds/plant than plants in de-flowered ($p=0.0001$) and flowering ($p<0.0001$) plots (Fig 6b). Plants in removal plots produced 8.04 times more seeds per plant on average than plants in plots containing *L. maackii.*
- Plants in removal plots received more mean rank pollinator visits per 10 minute intervals than plants in de-flowered ($p<0.0001$) and flowering ($p<0.0001$) plots (Fig 6c). Mean rank number of conspecific pollen grains per stigma was significantly lower in flowering vs. removal ($p<0.0001$) and de-flowered plots ($p=0.029$) (Fig 6d).

Mechanism

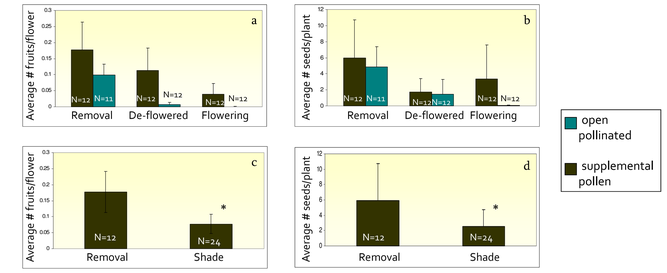


Figure 7. Pollen & light limitation were analyzed with Wilcoxin tests. Bars are means and error bars represent +1 SE:a,b,d; ±1 SE:c. Data are from 2008 only because 2007 hand pollinations failed.

- Fruit and seed set were not pollen limited in any treatments (Fig7a,b).
- De-flowered and flowering treatments did not differ in amount of light (Fig 3) and were combined to assess light limitation (Fig7c,d).
- Fruit and seed set of supplemental hand pollinated plants was higher in the removal vs. shade treatment (Fig 7c,d;$p=0.0231$, $p=0.0061$, respectively), suggesting that light availability limits fruit and seed set.

Conclusions

- **Light, not pollinator activity, limited reproductive output in *H. macrophyllum* (Fig 5) and *G. maculatum* (Fig 7a-d).**
- **Despite the presence of *L. maackii* flowers in the *G. maculatum* experiment, decreased light directly reduced reproductive output in both species (see excerpt from Fig 1 below).**

Hydrophyllum Macrophyllum

- As expected, shade from the *L. maackii* canopy (Fig 3) significantly reduced the number of pollinator visits/flower (Fig 4b), receipt of conspecific pollen grains (Fig 4c), and number of seeds/plant (Fig 4a) .

Geranium maculatum

- As expected, the presence of *L. maackii* reduced pollinator services and reproductive output of *G. maculatum* (Fig 6a-d). Hand pollinations revealed slight pollen limitation in all treatments (Fig 7a&b), but this difference was not significant.
- Contrary to predictions, *L. maackii* flowers do not have any additional effects on pollinator visitation and subsequent reproductive output of native plants above that of *L. maackii*-induced shade in the understory (Fig 6a, b, c).
- *Lonicera maackii* flowers may have a slight negative impact on reproductive output (see de-flowered vs flowering: Fig 6a,b). Because visitation was extremely similar (Fig 6c) between de-flowered and flowering plots, this slight decrease in fruit set may be due to higher loads of *L. maackii* pollen on stigmas in flowering plots. This hypothesis will be explored when 2008 pollen grains are counted.

Overall

- Invasive flowers have received much attention surrounding concern of interference in pollinator service to native plants. This study shows that invasive shrubs may change the structure of the forest understory and have direct negative impacts on pollinator service and understory herb reproduction.

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