Interspecific Co-flowering Prairie Plants Compete for Pollinators

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Introduction

Pollen limitation is prevalent in many species and can be especially worrisome in fragmented landscapes. Reproduction in the purple coneflower, *Echinacea angustifolia* (*Asteraceae*), which grows in small remnants of tallgrass prairie in North America, is pollen limited but not pollinator limited.

Pollen limitation of *Echinacea* increases with isolation of individual plants, decreases with size of population, and has a strong negative impact on reproduction. However, pollinator visitation does not explain the reduced reproductive success. Wagenius and Lyon (2010) found that plants in the densest and largest populations of *Echinacea* receive fewer pollinator visits yet have greater reproductive success than plants in small isolated populations, which receive more visits but have decreased reproductive success. Among the many prairie plants pollinated by native solitary generalist bees, interspecific co-flowering plants may either enhance pollination by attracting more pollinators, or reduce reproductive success through competition or interference with compatible pollen receipt (Feldman 2008, Mitchell et al 2009).

Questions:

- Are the co-flowering species surrounding *Echinacea* influencing pollinator visitation?
- Invasive species within the floral neighborhood influence the number of pollinators that visit *Echinacea*?

Echinacea angustifolia: A model prairie plant

- Family: *Asteraceae*
- Mating system: Self-incompatible, reproduces only by seed
- Life cycle: Perennial
- Pollination: Native solitary generalist bees, butterflies, flies, beetles

Methods

Study Area:

- 10 tallgrass prairie remnants in Douglas Co., Minnesota with purple coneflower populations.
- Prairie remnants persist along roadsides, by rail-road crossings, and in prairie preserves.

Pollinator Observations:

- 8 focal flowering *Echinacea* plants were randomly selected at each remnant on 4 dates during the flowering season.
- Focal plants were observed in random order for 8 minute periods each, between 8-11am (mean = 3.5 times per observation day).
- Observers recorded bee visitation. Visitation per focal plant was analyzed as a binomial.

Floral Neighborhood Characterization:

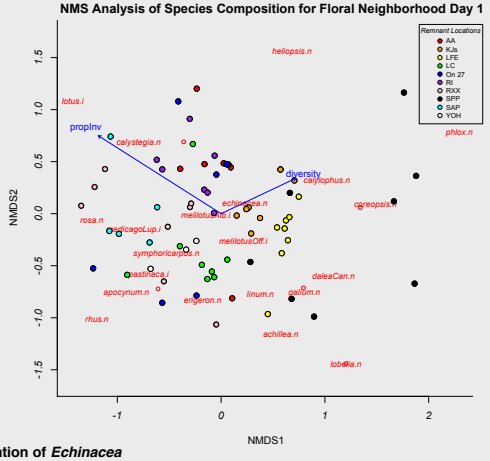
- Neighborhood includes all plants within 2 m of each focal plant.
- Co-flowering species were identified and inflorescences counted 3 times during the flowering season.

Results

Impact of co-flowering community on pollinator visitation of *Echinacea*

- Co-flowering species diversity was an inconsistent predictor of pollinator visitation. Proportion of pollinator visitation increased with diversity of the floral neighborhood for the final round of data collection only, 23-24 July ($p< 0.05$, df = 1, n = 75) according to generalized linear models with binomial response. Diversity did not explain the patterns of pollinator visitation at peak flowering or before.
- Non Metric Scaling (NMS) analysis was conducting using the metaMDS function with default settings in the vegan package with R for each floral neighborhood day (Oksanen et al. 2008). Dissimilarity was based on Bray–Curtis distances and plots were constructed using two dimensions. As expected, focal plants from the same sites tended to group together. Proportion of non-native species (propInv) was significant for ordination graphs of all three floral neighborhood collection times.
- NMS analysis of species composition for floral neighborhood day 1 indicates that diversity and proportion of non-native were significant vectors. Fitted vector arrows are significant ($P< 0.001$, by permutation procedure) and their length is proportional to their explanatory strength. Explanatory variables tested were the proportion of non-native species, propInv, ($P< 0.0001$) and the Shannon-Weaver diversity index ($P<0.001$). Species codes: genus.i or .n, where .i indicates introduced and .n indicates native.
- Although NMS analyses reveal patterns in co-flowering species composition. The floral neighborhood composition did not explain the patterns of pollinator visitation we observed.

NMS Analysis of Species Composition for Floral Neighborhood Day 1



Impact of most abundant co-flowering species on pollinator visitation of *Echinacea*

- 40 species co-flowered with *Echinacea*, 9 of which are invasive. Co-flowering species richness ranged from 14 in the largest remnant to 5 in the smallest.
- Alfalfa, *Medicago sativa* (*Fabaceae*), the most abundant exotic co-flowering species, occurred at 41 focal plants. Leadplant, *Amorpha canescens (Fabaceae)*, the most abundant native species (besides *Echinacea*), occurred at 99 focal plants. *Echinacea* plants tended to have either *Amorpha* or *Medicago* in their floral neighborhood (only 1/224 plants had both).
- *Echinacea* plants that had *Medicago*, *Echinacea*, or both species in their floral neighborhoods were more likely to receive a pollinator visit (23%, 23%, and 32% respectively) than those with neither *Medicago* nor *Echinacea* (16%, according to a generalized linear model with binomial response $p<0.03$).
- *Echinacea* plants that had *Amorpha* or both *Amorpha* and Echinacea in their floral neighborhoods were less likely to receive a pollinator visit (13% and 18% respectively) than those with only *Echinacea* or neither species (29% and 21% respectively, $p<0.02$).
- There is no evidence that *Medicago*, *Amorpha*, and *Echinacea* interact in their effect on pollinator visits.
- Despite this pattern with *Amorpha* and *Medicago*, the proportion of co-flowering invasive species at a site was not a significant predictor of pollinator visitation for *Echinacea*.

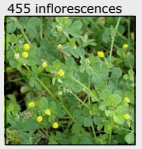
Most Abundant Co-Flowering Species: Non-Natives

Medicago sativa
Alfalfa
14474 inflorescences

Melilotus alba
White sweet clover
1022 inflorescences

Melilotus officinalis
Yellow sweet clover
906 inflorescences

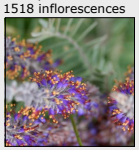
Medicago lupulina
Black medic
455 inflorescences



Lotus corniculatus
Bird's-foot trefoil
446 inflorescences

Most Abundant Co-Flowering Species: Natives

Amorpha canescens
Lead-plant
1518 inflorescences



Coreopsis palmata
Bird's-foot coreopsis
855 inflorescences

Symphoricarpos albus
Snowberry
505 inflorescences

Galium boreale
Northern bedstraw
206 inflorescences

Monarda fistulosa
Wild bergomot
179 inflorescences

Conclusions:

Neither the community of co-flowering species nor the presence of non-native plants was associated with variation in pollinator visitation.

Co-flowering species diversity was a predictor of pollinator visitation only late in the flowering season. Floral communities, as quantified by NMS analysis, were associated with the presence of non-natives all season long and overall diversity only in the early season. NMS characterizations of species co-flowering with *Echinacea* did not predict pollinator visitation at any time.

Echinacea neighborhoods with *Amorpha*, a native, had lower pollinator visitation, while the neighborhoods with *Medicago*, a non-native, had higher pollinator visitation.

We found no compelling evidence that interspecific co-flowering species influence pollinator visitation to *Echinacea* in small prairie remnants. The previously observed high pollinator visitation and concurrent pollen limitation might result from low quality of pollinator visits, an hypothesis we are now investigating.

Acknowledgements:

Thanks to A. Dykstra , A. Halverson, M. Jensen, D. Rath, C. Ridley, and R. Shaw for their help in the field, to C. Ridley, and D. Rath for their help with database analysis, to NSF-REU grant 0648972, and to the Chicago Botanic Garden REU program for their support.

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