Examining the patterns and implications of uninformative achenes in remnant populations of *Echinacea angustifolia*

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Introduction

Prairie fragmentation due to agricultural expansion threatens many native plant populations. The Echinacea Project studies reproductive fitness in the model plant *Echinacea angustifolia* to better understand reproductive consequences of habitat fragmentation.

Seed set is one measure of reproductive fitness, calculated as the proportion of informative achenes that contain embryos. Damaged or undeveloped "uninformative" achenes are not included in this count.

Here, we test hypotheses regarding the incidence of two types of uninformative achenes: those eaten by larvae, and those aborted early in their development, hereafter "tiny" achenes.

For example, we predict a relationship between population density and larval incidence. Discovering such a density-dependent relationship in *Echinacea* could help us understand general effects of larvae on reproductive fitness and consequences for population growth.

Hypotheses

The presence of a larva (≥1) can be predicted by:
- Seed head size (achene count)
- Seed set
- Population size
- Density of population (distance to 6th nearest neighbor)

The presence of a tiny (≥1) can be predicted by:
- Seed head size (achene count)
- Seed set
- Population size

Materials and Methods

In the summer of 2016, the Echinacea Project team randomly harvested 5 seed heads from 18 remnant prairie populations in western Minnesota. They also collected data on *Echinacea* populations.

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We removed achenes from each seed head, counted them, and separated them into stratified random samples of 90.

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We separated samples into informative achenes (which were x-rayed) and uninformative achenes (which were classified).

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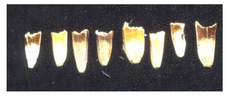
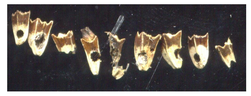
We classified x-ray images to determine the seed set (proportion of viable seeds) of each head.

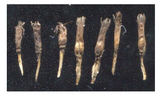
Echinacea achene classification



These disc achenes are classified as informative. They may or may not contain fertilized seeds; seed set is calculated using these achenes.

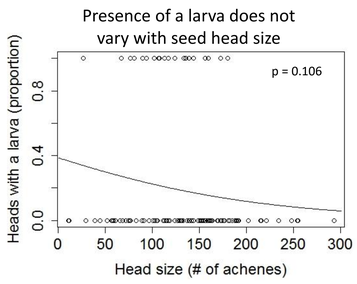


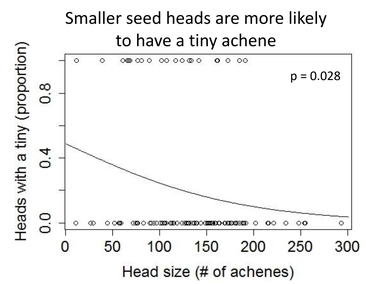
These achenes were eaten by larvae. These are classified as uninformative because any fertilized embryo may have fallen out of the achene or been consumed by the larvae.

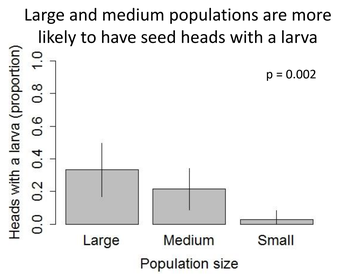


"Tiny" achenes were aborted early in their development; they are undersized and the floret is still attached. These are uninformative because they may or may not have been fertilized.

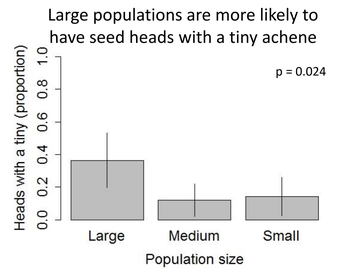
Results



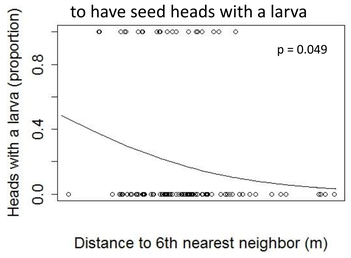




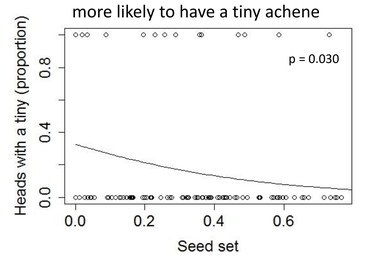
Small populations (# individuals = 0-25) are less likely to contain larvae than medium populations (# individuals = 26-100) or large populations (# individuals = 101-221). Error bars ± 2SE.



Large populations (# individuals = 101-221) are more likely to contain tinies than medium populations (# individuals = 26-100) or small populations (# individuals = 0-25). Error bars ± 2SE.



Density is measured by distance in meters to 6th nearest flowering individual; shown here on a logarithmic scale.



Results

In addition to the figures presented to the left, we also found:
- 8 out of 18 sites (44%) had a seed head with a larva. 44% of sites had a seed head with a tiny. However, there is little correlation between the incidence of the uninformatives ($p = 0.163$).
- Sample size of informative achenes decreases with the incidence of a larva by 13% ($p < 0.001$) and with the incidence of a tiny by 30% ($p < 0.001$).
- The effects of seed head size and population size on the incidence of a tiny are independent, but overlapped. This is likely because larger seed heads are more prevalent in smaller populations ($p = 0.004$).

Conclusion

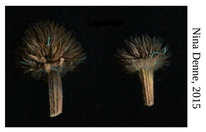
Population size and density directly predict the proportion of seed heads with a larva, thus larvae have a density-dependent relationship with *Echinacea* populations. Further studies could examine the life cycles of these larvae, and the extent to which they affect the reproductive fitness of *Echinacea* and other prairie plants.

While seed set is not linked to the incidence of larvae, low seed set predicts higher proportions of seed heads with a tiny achene. This implies that larvae should not impact reproductive fitness. However, further research into the genetic or external causes of tiny achenes would tell us about reproductive fitness of *Echinacea*.

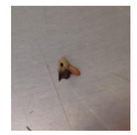
Tiny achenes occurred more often on small heads, which informs our understanding of fitness. The prevalence of tiny achenes in larger populations would defy an easy explanation, except that the mean size of seed heads in large populations is relatively small. This relationship does not imply causality, though it does indicate that further analysis into the causes of tiny achenes relative to both populations and head size would be helpful for conservation scientists.

It is important to note that data were collected in 2016. External factors potentially influencing larvae populations and abortion of achenes may be specific to this year.

A flowering *E. angustifolia* head



Two seed heads from which the achenes were removed



A larva emerging from an achene

Acknowledgments

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References

Ison, J.L. & Wagenius, S. (2014). Both flowering time and distance to conspecific plants affect reproduction in *Echinacea angustifolia*, a common prairie perennial. *Journal of Ecology, 102*(4), 920-929. doi: 10.1111/1365-2745.12262

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