Fitness and heritability in *Echinacea angustifolia* and *E. pallida* hybrids

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Introduction

Prior to European settlement, tallgrass prairie occupied a large portion of the central United States; today, however, prairie remnants occur in small isolated patches in areas deemed unfit for agricultural production (Wagenius et al., 2011). Along with fragmentation, the genetic integrity of extant species is threatened by the widespread introduction of non-native relatives.

This study focuses on the effects of hybridization between the purple coneflower native to Minnesota (*Echinacea angustifolia*) and *Echinacea pallida*, an introduced variety. Physiological measurements of 1 year-old seedlings were analyzed to discern variations in trait heritability and fitness among each cross type. To date, little research has been done to determine the effect of gene flow on hybrid fitness in restoration projects (Van Gaal et al., 1998).

Research Objectives

- Do early observations suggest that hybridization of *E. angustifolia* with *E. pallida* result in F1 progeny with different fitness levels relative to the P generation?
- Do physiological characteristics vary significantly among the progeny of all possible crosses of *pallida* and *angustifolia*? Is it possible to predict survival rates and fitness characteristics for each of these groups through aster modeling?
- How closely do the observed phenotypes of hybrid offspring correspond to those of their *pallida* and *angustifolia* parents? What does this suggest about the heritability of the traits under study?

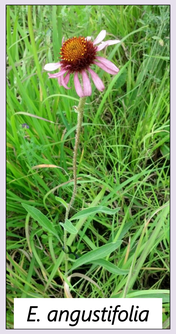
Materials and Methods

Research was conducted at the Hegg Lake State Wildlife Management Refuge (N˚ 45.78, W˚ 95.69) in an experimental plot (10m x 30m).

Characteristics measured for all cross-types and their parents:

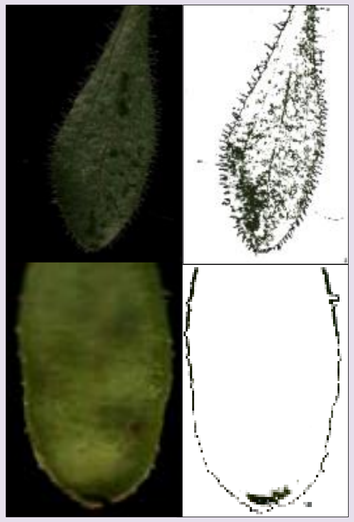
- Height
- Length of longest leaf
- Width of longest length
- Leaf number
- Trichome density (obtained from leaf scan images analyzed in GIMP and ImageJ)

In R, aster modeling was used to generate a quantitative comparison of fitness among the cross-types (Shaw et al., 2008).



E. angustifolia

E. pallida



Results

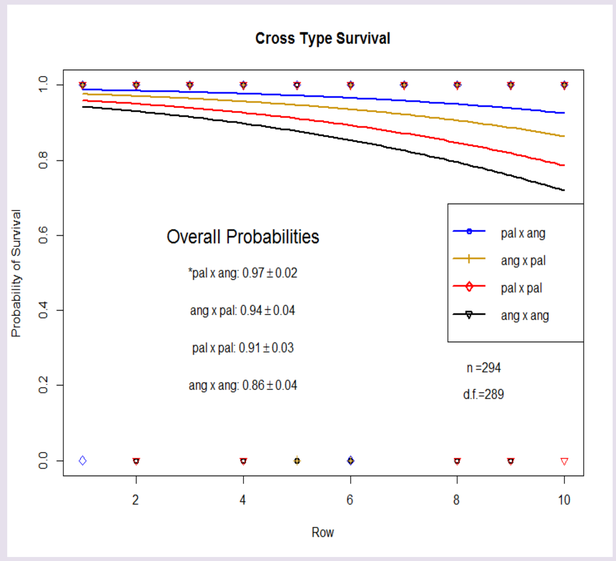


Figure 1. Generalized linear model depicting the probability of survival curves for each of the four cross-types. Mortality tended to increase in rows on the East side of the plot for all groups. Pr(>Chi) = 0.077 from a two-way ANOVA evaluating the significance of cross-type in accounting for survival.

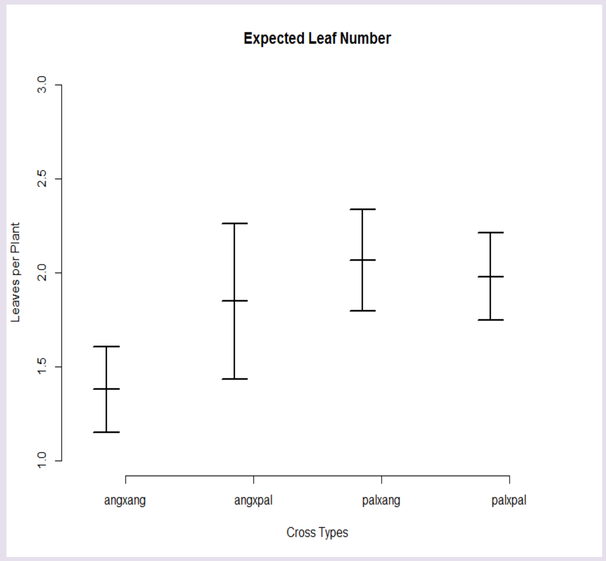


Figure 2 . Fitness results from an aster analysis. After accounting for mortality, the *pallida x angustifolia* cross-type is expected to have the greatest leaf number (Pr(>z)= 3e-04).

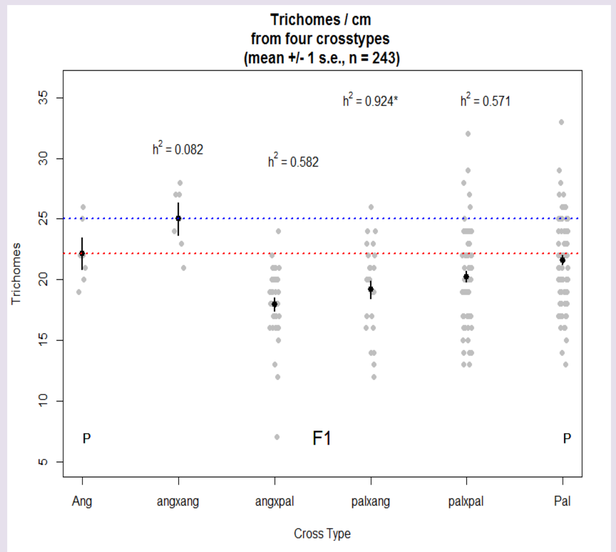


Figure 3 . Heritability of trichome density, measured as the number of marginal trichomes 1 cm from the leaf tip. Seedlings with leaves smaller than 1 cm in length were excluded from the analysis. Estimates of h^2 were generated from a linear model of progeny trichome density on parental values. The dashed lines indicate mean parental values.

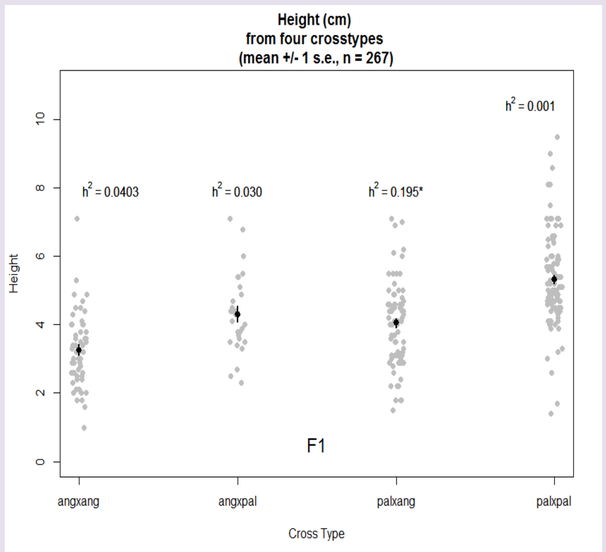


Figure 4. Heritability of height; h^2 values were estimated from linear models generated in R. Error bars represent ±1 standard error about the mean. Of the two hybrid cross-types, only *pallida x angustifolia* has moderate heritability for height. This result can perhaps be attributed to a maternal effect.

Conclusion

This study is the first phase of a long-term experiment identifying the possible ecological and evolutionary consequences of hybridization between *E. angustifolia* and *E. pallida*. The results indicate that both hybrid cross-types are more likely to survive through their first year than either the pure *pallida* or *angustifolia* offspring. The *pallida x angustifolia* cross-type has also demonstrated a faster above-ground growth rate: a feature that may indicate higher overall fitness.

Future directions for this project include the continued collection of morphological measurements. This data will be useful in getting more accurate predictions of overall fitness and phenotypic traits among each cross-type. Analysis of hybrid fecundity and F2 generation characteristics will illuminate *E. pallida*'s long-term effects on the population dynamics of *E. angustifolia.*

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