Evidence of geographic local adaptation in fitness and growth traits of *Asclepias syriaca*

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Introduction

As the sole food source for the larvae of declining populations of monarch butterflies, Asclepias syriaca (common milkweed) restoration efforts have intensified to increase and protect the butterfly populations. As restoration is a time- and resource-intensive process, investigating whether A. syriaca exhibits local adaptation along geographic lines or based on climatic similarities is paramount for successful restoration efforts. In our common garden provenance trial, we are looking at how growth, defense, and stress traits are impacted by geographic distance and related abiotic factors.

Methods

- We planted seeds from 178 full-sibling families from 20 source populations representative of *A. syriaca* range in the United States.

- Each full-sibling family, or genotype, was represented in six replicated but individually randomized plots in the St. Olaf natural lands.

- We took measurements related to growth, defense, and stress in June-July 2021.
  - Measurements included plant height, length/width of largest leaf, leaf number, latex weight and trichome count.
  - Stress score was determined on a 0-3 scale, with 0 being "unstressed" and 3 being "on death's door". Each plot was measured by a single researcher in order to keep a consistent scale within plots.

- All statistical analysis was completed using the program R.

More Info

Common milkweed shows signs of local adaptation under specific conditions

Stressed *Asclepias syriaca*
Photo by Madelyn Wood

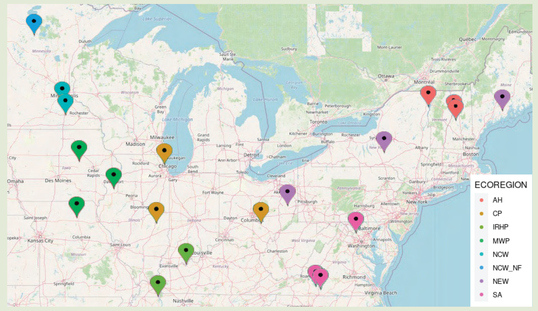

Fig 1. Locations of seed collection sites, color-coded by ecoregion.

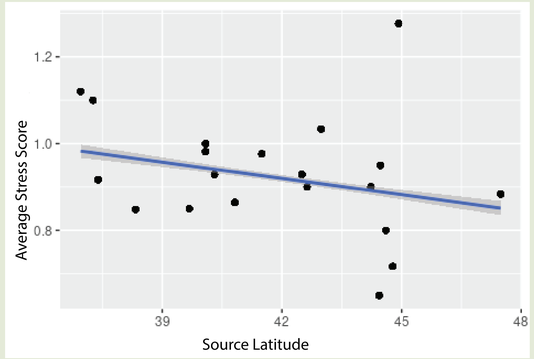

Fig 2. Stress score averaged by source plotted by latitude of the seed source (p-value = <2e-16).

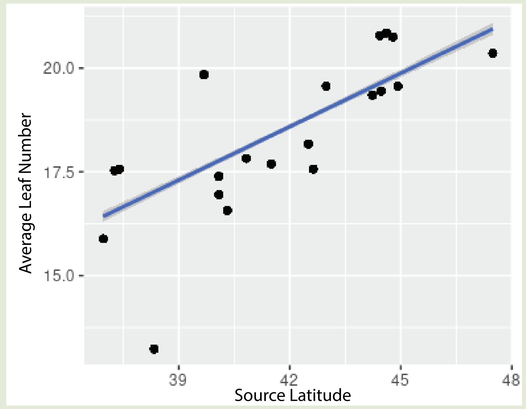

Fig 3. Average leaf number by source plotted by source latitude (t-value = 37.188, p-value = <2e-16).

Results

We found that average stress response is significantly correlated with source latitude (p = <2e-16) based on a linear model. Stress response is significantly correlated with source longitude (t = -2.319) based on a linear mixed-effects model of stress score as a function of longitude. We also found that average leaf number by source was correlated positively with latitude based on a linear model of average leaf number by source as a function of the source latitude of the plant (t = 37.188, p ≈ 0). A linear mixed-effects model of peak leaf number as a function of source latitude, accounting for the random effects of plot, source and genotype within each source, as well as the fact that the plants began with different numbers of leaves at the moment they were planted in the field (highly correlated with peak leaf number, t = 17.466) also demonstrated a significant relationship between leaf number and latitude (t = 5.453).

Discussion

- Average stress response increased as source latitude decreased and source longitude increased.

- The correlations between stress and leaf number with source latitude provides evidence for local adaptation. Generally, correlation with different environmental factors is trait specific (Bucharova et al. 2017). This means that certain environmental factors can explain some evidence of local adaptation, but not all.

- The relationship between leaf number and latitude of origin is only visible for the peak measurement. Several studies have reported evidence of trait-specific clinal variation based on latitude and/or climate at specific times in a plant's growing season (Frank et al. 2017; Stock et al. 2014) including in milkweed (Finch et al. 2018). This points toward phenology as a factor in the expression of local adaptation.

-The relationship between latitude and stress/growth factors provides evidence for local adaptation, so sourcing seeds within a climatic region is recommended for restoration. However, our longitudinal data requires further exploration before we make decisive conclusions.