Indirect interactions in agricultural milkweed habitat: the effects of root damage on monarch (*Danaus plexippus*) success

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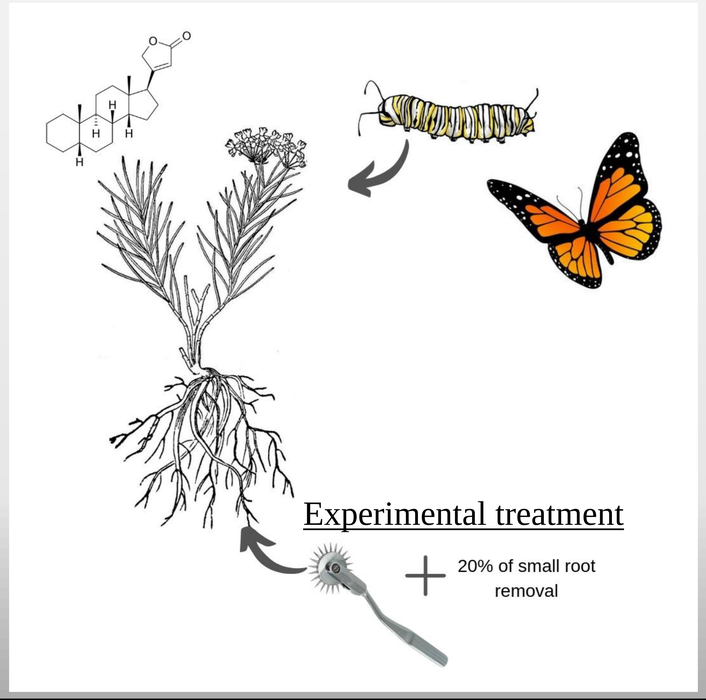
Introduction

Monarch caterpillars eat milkweeds (genus *Asclepias*) and sequester the toxic chemicals that the plant produces, which makes the monarchs poisonous to predators as adults. Trophic interactions in both leaves and roots can affect host plant chemistry, but little research to date has focused on how root damage affects monarch success indirectly, via host plant defensive compounds.

Questions

- How does mechanical root damage affect defensive compounds in milkweed?
- How does root damage affect monarch caterpillar development and butterfly performance?



Methods

- *Asclepias fascicularis* seeds were germinated and grown in the UNR greenhouse for 3 months
- 50% of plants were subjected to mechanical root-damage (treatment), while 50% were damage-free (control)
- 8 first-instar monarch caterpillars were fed root-damaged plants and 8 caterpillars were fed control plants until the chrysalis stage
- I measured milkweed defensive compound production, the caterpillars' daily weights, and metrics of butterfly success

Results

Defensive compound production in milkweed

- Higher cardenolides in the leaves of root-damaged plants
- Diversity of flavonoids was higher in root-damaged plants

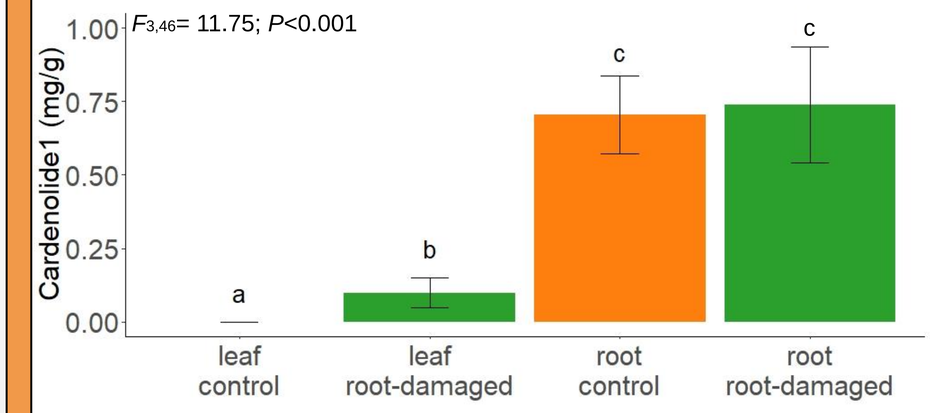


Fig 1. *Asclepias fascicularis* cardenolide concentrations in the leaves and roots of control (damage-free) and root-damaged plants.

Monarch caterpillar development

- No change in amount of time spent in developmental instars
- Caterpillars feeding on root-damaged plants were smaller (Fig 2A) and spent less time in the chrysalis (Fig 2B)
- 62.5% of caterpillars feeding on root-damaged plants died (Fig 3)

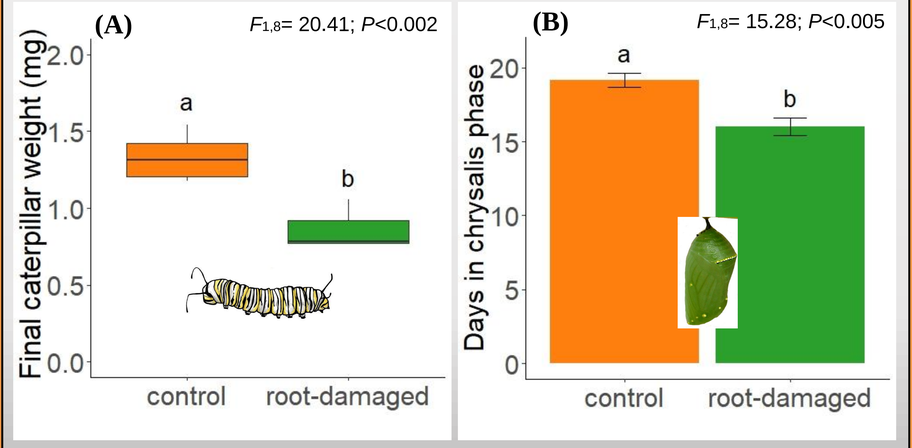


Fig 2. (A) Final weight (mg) comparison between monarch caterpillars feeding on control (damage-free) and root-damaged plants. (B) Number of days in chrysalis phase between caterpillars raised on control and root-damaged plants.

Results

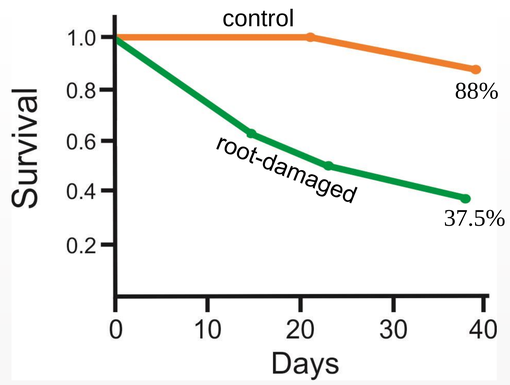


Fig 3. Proportional survival for monarchs during their larval and pupal phases when raised on control and root-damaged milkweed plants.

Monarch butterfly performance

- Butterflies raised on root-damaged plants were smaller and had smaller wings (Fig 4).

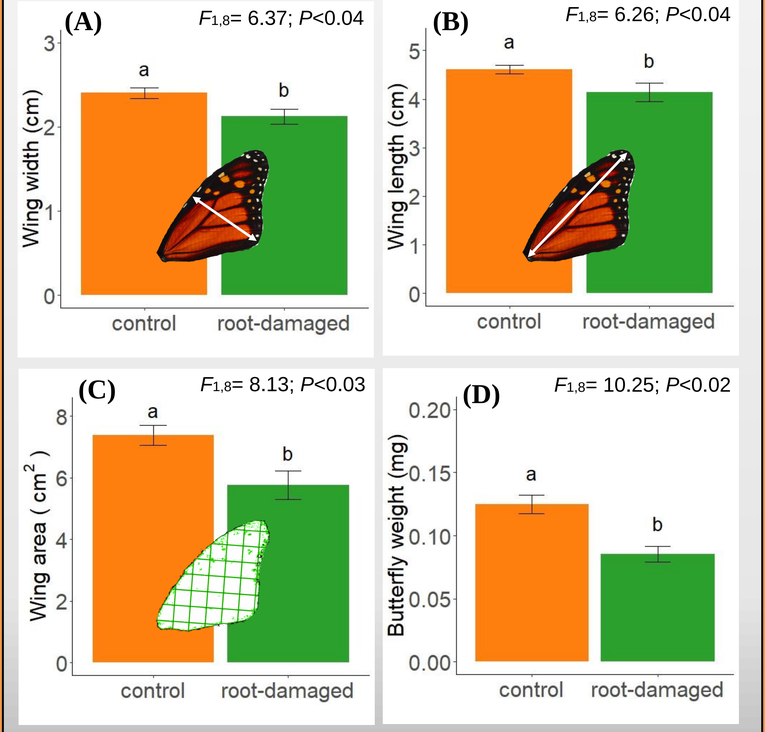


Fig 4. (A) Wing width, (B) length, (C) area, and (D) adult dry weight of monarch butterflies raised on control and root-damaged milkweed plants.

Conclusions

Damage to milkweed roots, which is common in nematode-rich soils adjacent to agricultural systems, hinders monarch success across multiple life stages. Root-damaged milkweed plants have more defensive compounds, and monarch development and performance are negatively affected on these plants. Caterpillars on root-damaged plants develop more quickly, have lower survival, and the survivors are much smaller. Monarchs rely on milkweed plants as their food source, and root damage is likely detrimental to monarch populations.

Acknowledgments

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