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Effect of Decreased Snowfall During an Atypical Winter on a Rare Butterfly's Host Plant

Breelyn Gilbert
Providence College

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Breelyn Gilbert & Rachael Bonoan
Biology, Providence College, Providence, RI
bgilber3@friars.providence.edu

BACKGROUND

In the Northeastern US, one result of climate change is decreased snowfall and earlier snowmelt. Such changes can alter the relationship between climate and the timing of cyclical biological phenomena— the **phenology** of organisms. This is especially concerning for species that interact with one another such as butterflies and their host plants (1).

For this study, I focused on the **host plant of the rare frosted elfin butterfly**. The frosted elfin is a species of concern in RI, MA, and CT, among 8 other states, and they are a host plant specialist only laying eggs on yellow wild indigo *(Baptisia tinctoria*) and wild lupine (*Lupinus perennis*). If these plants do not emerge and develop leaves when the butterflies lay eggs, the effect would be catastrophic on successive populations. In addition to possible mismatched emergence of the butterfly and its host plant, these phenological changes could also affect **host plant nutritional quality** (2)**, directly impacting the caterpillars' only food source**. I focused on plots of indigo at Gavins Pond in Foxboro, MA, which were set up before Winter 2021-2022. Following Winter 2021-2022 and Winter 2022-2023, **I measured plant growth and sampled plants for elemental analysis**. I predict wild indigo growth in Summer 2023 will be expedited after the minimal snowfall during the Winter 2022-2023 compared to the growth following Winter 2021-2022. I anticipate this expedited growth will result in lower nutritional quality of the host plant during frosted elfin oviposition (egg-laying).

RESULTS

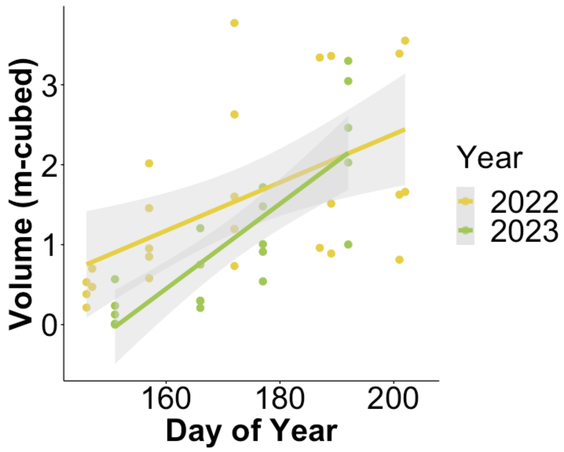

Figure 4. Growth of indigo compared after two winters as characterized by volume

On average, the difference in growth of the indigo between the years of 2022 and 2023 approached significance (LM, F = 3.418, df = 1, p =0.07171) (Figure 4).

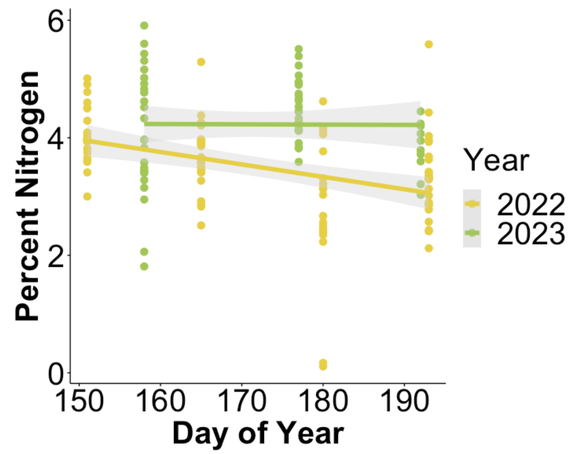

Figure 5. Comparison of nitrogen content in indigo samples collected After two winters

On average, indigo plants had significantly more nitrogen (%) in 2023 than in 2022 (LM, F = 11.7238, df = 1, p = 0.0007985). Furthermore, nitrogen decreased over time in 2022, but not in 2023 (year*doy interaction: LM, F = 4.4318, df = 1, p = 0.0369637) (Figure 5).

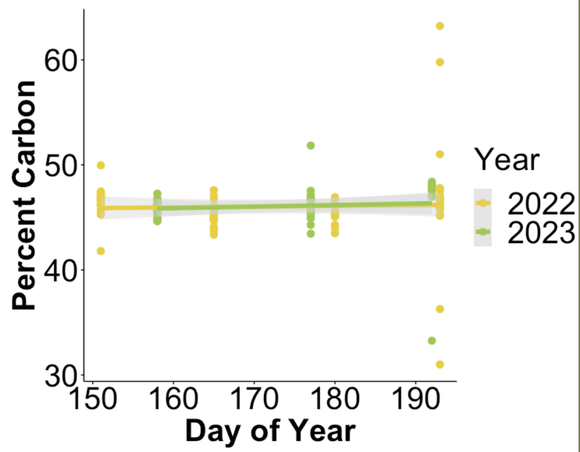

Figure 6. Comparison of carbon content in indigo samples collected after two winters

On average, indigo plants had no significant difference in carbon (%) between 2023 and 2022 (LM, F = 0.3388, df = 1, p = 0.5614) or over time (LM, F = 0.0464, df = 1, p = 0.8298) (Figure 6).

MATERIALS AND METHODS

- 5 Plots of 3x3m were marked off in a patch at Gavins Pond in which wild indigo was abundant (Figure 1)
- Every other week during the past two summers, **5 samples of indigo were collected from each of these 5 plots** (Figure 2) and **growth and development were tracked**
- The samples were run through a **freeze-drying** cycle
- After freeze drying, the samples were packed, weighed, and then combusted in an **elemental analyzer** (Elementar UNICUBE for CHNS)
  - The Elementar determines % nitrogen and % carbon of the samples

Figure 1. Roped off plots created at Gavins Pond

Figure 2. Tip of indigo leaf held in fine forceps

CONCLUSIONS

Growth

The growth data between the two years was not significant, however, **data collection is still ongoing**. With one more set of volume measurements to be added to the 2023 data, it is likely the growth would be pulled even further in the upwards direction. When looking at the plot, you can see that although the 2023 growth begins smaller (which we speculate could be due to the cold snap during the 2022-2023 winter (4)), it is a steeper slope with which the growth increases. This suggests the lack of snowfall may have expedited the plants overall growth in the long-run for the season.

Nutritional Content

Though the carbon content remained roughly the same between the two years studied, there was a significant difference in the nitrogen content. This is of particular importance because butterflies sequester the vast majority, if not all, of their nitrogen from larval nutrition (3). Unexpectedly, the 2022 indigo showed a decrease in nitrogen content as time progressed, while the 2023 indigo nitrogen content remained relatively higher and steady over time. Counter to my prediction, it appears there was more nutrition available during larval development in 2023. This could be due to the indigo starting the season out smaller in 2023 than in 2022 and having a greater capacity for above ground nutritional density.

References

1.Kharouba and Vellend, 2015. *Flowering time of butterfly nectar food plants is more sensitive to temperature than the timing of butterfly adult flight* **2.**Stephanie S. Bauerfeind, Klaus Fischer, 2013. *Increased temperature reduces herbivore host-plant quality* **3.**K. Fischer, D. M. O'Brien and C. L. Boggs, 2004. *Allocation of Larval and Adult Resources to Reproduction in a Fruit-Feeding Butterfly* **4.**Gemma Woldendorp, Michael J. Hill, Ruth Doran, Marilyn C. Ball, 2008. *Frost in a Future Climate* **5.**Diane M. O'Brien, Carol L. Boggs, Marilyn L. Fogel, 2005. *The Amino Acids Used in Reproduction by Butterflies*

Acknowledgments

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