Impact of Drought on Plant-Herbivore Interactions

Laura Fehling[1], Katherine Andrews[2], Krissa Skogen[3]
University of Wisconsin-Green Bay[1], Northwestern University[2], The Chicago Botanic Garden[3]

Introduction

Figure 1. *Oenothera harringtonii* flower

Water availability is a vital factor in a plant's ability to grow and reproduce. As global climate change intensifies, more areas suffering from extreme conditions (Hoerling 2003). As precipitation patterns change, many areas suffer from increased drought or flood frequency and intensity. Decreased water availability can alter plant morphology and floral traits, potentially leading to a negative impact on plant relationships with herbivores. In this study, we conducted assessed the impact of precipitation (watering) frequency of an evening primrose, ***Oenothera harringtonii,*** on the performance of an important herbivore, ***Hyles lineata***.

Figure 2. *Hyles lineata* caterpillars

Figure 3. *Hyles lineata* hawkmoth

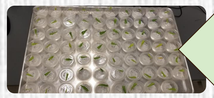
Hypotheses

As watering frequency increases the following metrics will decrease:

1. Neonate relative growth rate
2. Neonate relative consumption rate
3. Neonate efficiency of conversion of digested food
4. Neonate survivorship

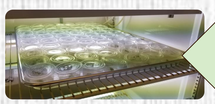
Methods

Leaves were collected from plants grown under one of five watering frequencies (every 1, 2, 3, 9 and 12 days)



A Solo cup was prepared with filter paper, DI water, and label.

Neonates and leaves were weighed and placed into Solo cups.



Neonates fed for 72 hours in an incubator (at 12 hour cycles of day at 25°C and 15°C night) and then weighed.

Neonates and leaves were dried in an herbarium dryer for 4-5 days.

Neonates and leaves were weighed for a final dry weight.

All wet weights of leaves and neonates were converted to dry weights for calculations of growth rate, consumption rate, and efficiency of conversion of digested food.

Results

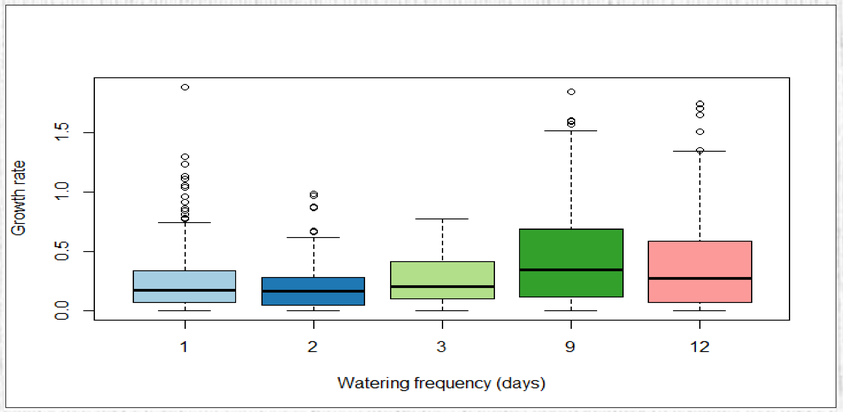


Figure 4. Neonate growth rate (weight gain / initial dry weight (mg) /days feed) across treatments (mean+/- 1 s.e., 1(N=229), 2(N=184), 3(N=26), 9(N=126), and 12(N=134)). Neonate growth rates were significantly higher when plants were watered every 12 days than when watered daily (p=0.0002) or every second day (p<0.0001) and when watered every 9 days than when watered daily (p<0.0001) or every 2 days (p<0.0001). Growth rate was significantly different between blocks.

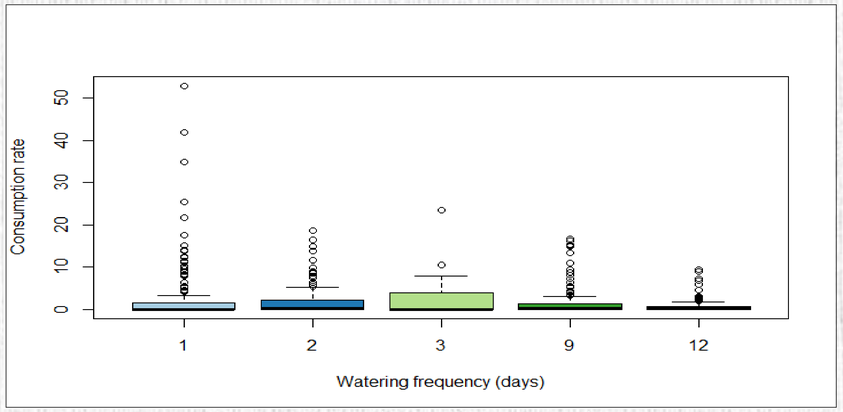


Figure 5. Neonate relative consumption rate (consumed plant weight / caterpillar initial dry weight (mg) /days feeding) across treatments (mean+/- 1 s.e., 1(N=172), 2(N=139), 3(N=25), 9(N=196), 12(N=163)). Neonate consumption rate was significantly higher when plants were watered daily than every 12 days (p=0.0007).

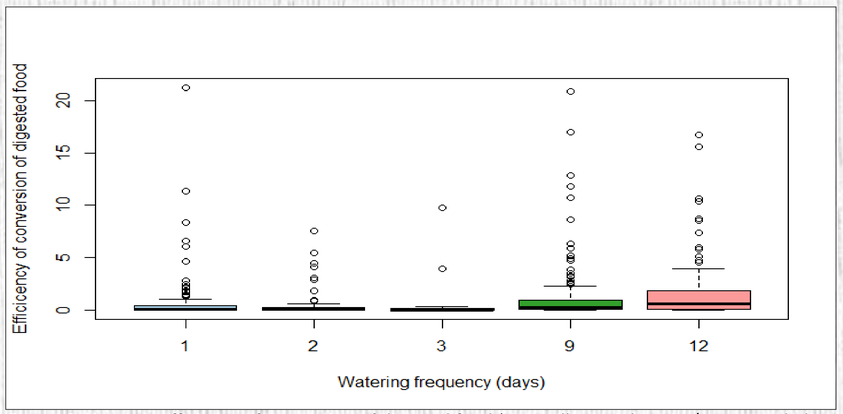


Figure 6. Neonate efficiency of conversion of digested food (caterpillar weight gain / consumed plant weight) across treatments (mean+/- 1 s.e., 1(N=109), 2(N=100), 3(N=16), 9(N=132), 12(N=114)). Neonate efficiency of conversion was significantly higher when plants were watered every 12 days than when watered daily (p=0.005).

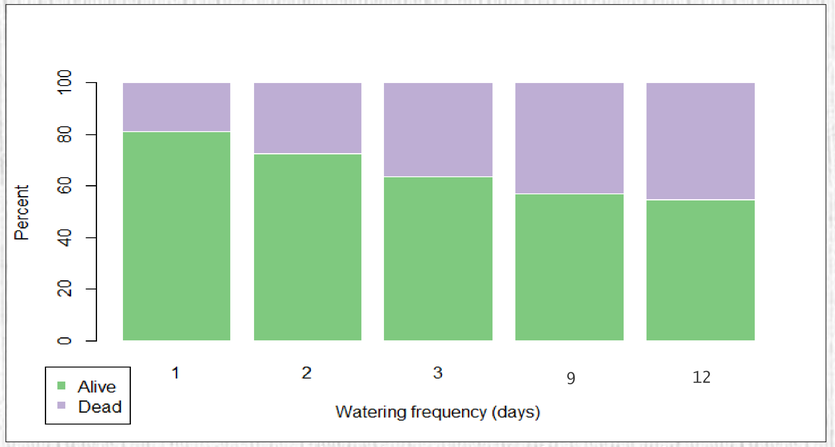


Figure 7. Percent neonate survivorship and mortality across five watering frequencies (1(N=259), 2(N=219), 3(N=33), 9(N=205), 12(N=190)). Mortality increased with decreased watering frequency.

Discussion

Neonate growth rate, consumption rate, and efficiency of conversion of digested food were determined by comparing initial and final neonate / leaf weights throughout the study. The results suggest that neonates on most water-stressed plants grow larger, consume less, but have a higher efficiency of digestion. Growth rate was significantly higher in plants with watering frequencies 9 and 12 compared to watering frequencies 1 and 2, supporting the first hypothesis (Fig 4). Consumption rate was significantly higher in plants with watering frequency 1 compared to watering frequency 12, rejecting the second hypothesis (Fig 5). Efficiency of conversion was significantly lower in plants with watering frequency 2 compared to watering frequency 12, supporting the third hypothesis (Fig 6). Neonate survivorship was decreased with decreased watering frequency, rejecting the fourth hypothesis (Fig 7). Growth rate may be higher in plants with lower watering frequency due to their increased efficiency of conversion of digested water-stressed leaf material. The lower consumption rate in plants watered less frequently may be related to increased plant defenses triggered by drought (Mattson 1987). Water-stressed plants may increase their defenses to protect themselves from increased herbivory. These defenses may decrease an herbivore's ability to consume enough plant material, resulting in starvation and lower survivorship. Consumption rate may have been higher in plants watered more frequently due to less defenses and increased nutrients associated with water availability (Gutbrodt 2011). Future studies should include an increased sample size, greater range of watering frequencies, and analysis of leaf defenses. The relationship between drought and herbivory is important in understanding plant-insect interactions with ongoing climate change.

Acknowledgments & References

I would like to thank Haley Carter and Tania Jogesh for their help and advisement with the project and the Chicago Botanic Gardens for access to technology and facilities and the NSF. REU Site: Plant Biology & Conservation Research Experiences for Undergraduates - From Genes to Ecosystems (Supported by NSF award DBI-1757800).

References: Gutbrodt, B., Mody, K., & Dorn, S. (2011). Hoerling, M. (2003). Mattson, J., Hack, R. (1987).

Contact: Laura Fehling: lsfehling@gmail.com