Effects of temperature and rainfall manipulation on insect and pathogen damage to *Solidago canadensis*

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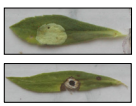
Objective

Global climate change models predict more variable precipitation patterns (larger rainfall events separated by longer dry periods) as well as increased temperatures. Field studies addressing the responses of insect herbivores and plant pathogens to these types of forecasted changes are rare.

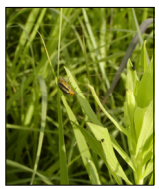
How will predicted climate changes affect levels of insect herbivory and pathogen damage in plants?

In this study, we compare insect herbivory and pathogen damage in the common forb, *Solidago canadensis* (Canada goldenrod), under the rainfall and temperature treatments of the Rainfall Manipulation Plots (RaMPs) at Konza Prairie.

One of 3 blocks of plots in the RaMPs experiment, with 2 ambient rainfall shelters, 2 delayed rainfall shelters, and an unsheltered control plot.



Typical pathogen damage (above), and a common *Solidago* herbivore (right).



Methods

RaMPs experimental design

The RaMPs experiment at Konza Prairie consists of 12 plots with experimental shelters and 3 unsheltered control plots. In 6 shelters, intercepted rainfall is applied to the plots with each natural rain event (ambient treatment). In the remaining 6 shelters, application of intercepted rainfall is delayed to increase inter-rainfall dry periods by 50% (delayed treatment). All 15 plots are divided into 4 2×2-m subplots: 2 ambient-temperature controls and 2 warmed by infrared lamps.

Herbivore and pathogen damage estimation

In each subplot, we measured damage on 3 randomly chosen plants separated by at least 0.5 m. We surveyed damage in mid-June (15-23 June 2005) and in late September (24-29 Sept 2005). Damage was scored on a 6-point scale (0: 0%, 1: <5%, 2: 5-10%, 3: 10-25%, 4: 25-50%, 5: 50-75%, 6: 75-100%). In June we scored damage on every leaf and estimated damage/plant as the mean % damage per leaf (>6300 leaves from 177 plants). A wire was placed around the shoot at the same leaf position for all plants to mark new leaves produced after the June survey. In September, we scored all the leaves above this wire (>3000 leaves from 172 plants). In this second survey, we distinguished insect herbivory from pathogen damage, which was much more common later in the season.

Leaf quality measurements

In June, we collected one fully expanded leaf from approximately the same position on each plant. We measured wet weight, dry weight, and leaf area of each leaf to determine leaf water content (%) and specific leaf mass (mg/cm^2). We measured %C and %N of ground leaves on a C/N autoanalyzer (Carlo-Erba 1500C).

Plant damage

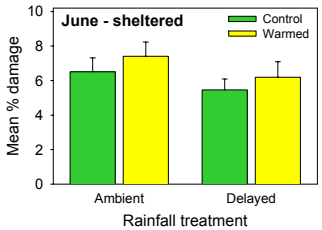


Fig. 1. We observed a marginally significant effect (p=0.053) of rainfall treatment on leaf damage in the sheltered plots in June: plants in the ambient treatment experienced more damage.

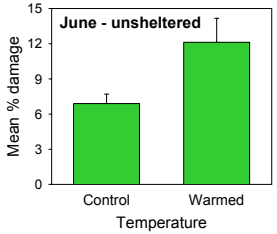
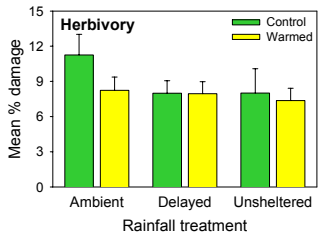


Fig. 2. In the unsheltered plots, plants in the warmed subplots experienced significantly higher damage (p=0.031) than plants in the control subplots.



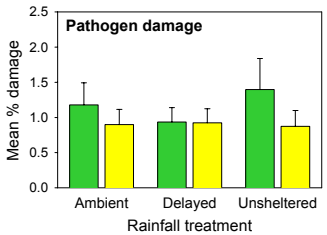


Fig. 3. The rainfall and temperature treatments had no effect on either herbivory or pathogen damage later in the season (September survey).

Leaf quality measures

Preliminary analysis of leaf %C and %N (sheltered, control-temperature plots only, n=71) revealed no effect of rainfall treatment on leaf C:N.

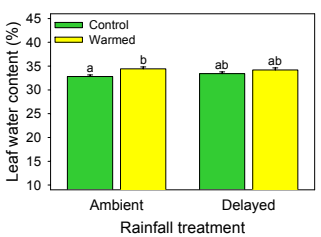


Fig. 4. Temperature, but not rainfall treatment, had a significant effect (p=0.005) on leaf water content.

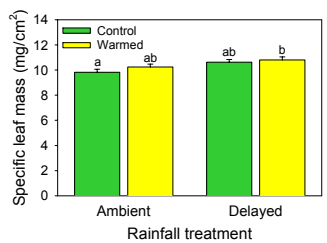


Fig. 5. Rainfall treatment, but not temperature, had a significant effect (p=0.005) on specific leaf mass.

Relating damage to leaf quality

In sheltered plots (ambient and delayed rainfall), damage was not related to either leaf water content or specific leaf mass.

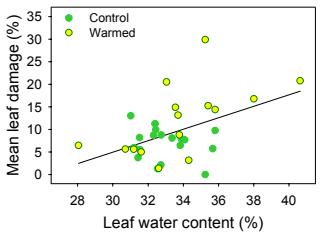
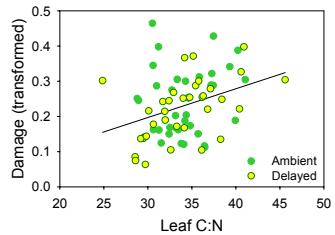


Fig. 6. In the unsheltered plots, we found a significant positive relationship between leaf water content and early season damage (r^2=0.215, p=0.006).

Fig. 7. In the sheltered control-temperature plots, we observed a weak but significant positive relationship between leaf C:N and early season damage (r^2=0.11, p=0.004).



Conclusions

- Effects of warming and prolonged dry periods on insect herbivory were weak and limited to the early growing season. Pathogen damage did not respond to climate manipulation. One season of sampling is likely not sufficient to detect treatment effects on inherently variable insect and pathogen responses.
- Herbivore responses to variation in leaf quality are difficult to interpret: in unsheltered plots, damage increased with higher quality (higher % water) leaves, while damage declined with higher quality (lower C:N) leaves in sheltered, control-temperature plots.
- Interpreting insect responses to climate-related manipulations requires more information about the feeding behavior and scale of movement of major herbivores. In addition, insect responses to climate change may depend on how microclimate influences foraging decisions and residence time in host plant patches.
- Predicting the effects of forecasted climate changes on rates of damage from insect herbivores and plant pathogens is not straightforward.

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