Species-specific tree leaf comparison in the absence of bird predation on caterpillars

Stephanie Parker

California State University, Chico – MATH 615

Introduction

- Within a community structure, the primary producers (plants) are consumed by primary consumers (herbivores) and this relationship is maintained by secondary consumers (predator of the herbivore).
- Understanding these relationships between different trophic levels is fundamental to the study of community ecology (Fretwell, 1987). With the upset of one of these levels, we observe cascading effects through the ecosystem.

Research Question:

With the exclusion of the secondary consumer, how is the primary producer impacted?

Hypothesis:

If predatory birds are removed from a site (bagged branches), and the caterpillars are protected, then there should be a decrease in the number of leaves and the area of leaves on these trees. This is due to increased consumption from the unchecked caterpillar population.

Data

Table 1: Variables of Interest
N = 110

Variables	Description	%N
Tree Species	Red Maple (*Acer rubrum*)	21.1%
	Black Birch (*Betula lenta*)	5.4%
	Hickory (*Carya* spp.)	11.9%
	American Beech (*Fagus grandifolia*)	5.3%
	Witch Hazel (*Hamamelis virginiana*)	13.5%
	Black Cherry (*Prunus serotina*)	16.9%
	White Oak (*Quercus alba*),	13.9%
	Red Oak (*Quercus rubra*)	11.9%
Branch Treatment	Bagged Branches	67.6%
	Unbagged Branches	32.4%
		Mean
Number of Leaves	The number of leaves on the measured branches	291.1
Total Leaf Area	The total area of the leaves (m^2) of the measured branches. This was calculated from the number of leaves and the average leaf area.	0.853

This study analyzes data collected by the Singer Lab at Wesleyan University at three State Parks in Middlesex County, Connecticut in June and July 2008-11 (Singer et al. 2012). The branches of different tree species were either left unbagged allowing bird access, or bagged, preventing bird access.

Methods

- Multivariate modeling was conducted using multiple linear regression to investigate the relationship between total leaf area, number of leaves, and tree species. Correlation coefficients were analyzed to determine the strength of this linear relationship.
- An additional multivariate linear regression model investigated the relationship of those same variables with branch treatment.

Results

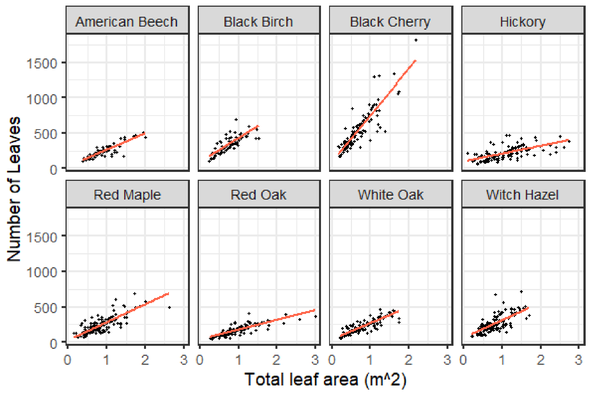
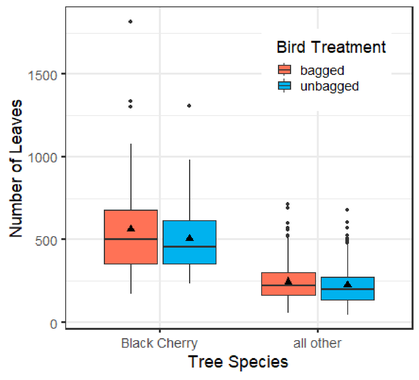


Figure 1. Overall leaf characteristics of each tree species

- There is a significant positive linear relationship between total leaf area and number of leaves for all tree species ($p<0.0001$).
- The correlation coefficient, r, of the linear relationship of between the total leaf area and number of leaves of each species is strongly positive ($r>0.6$).
- The majority of tree species have similar linear relationships between these variables. However, Black Cherry has a notably steeper slope than those of the other tree species and a greater number of leaves.

A



B

	Dependent variable:	
	Number of Leaves	
Total Leaf Area (m^2)	***232.2	(219.8, 244.5)
Trees other than Black Cherry	***-353.5	(-367.1, -399.9)
Branch Treatment: Unbagged	*-12.9	(-23.9, -2.1)
Adjusted R^2	0.6	

*Note: *p<0.05, ***p<0.001*

Figure 2. Multivariate model

- With notable variation between the characteristics of Black Cherry and the other tree species observed, these tree species were grouped to compare number of leaves on bagged and unbagged branches to Black Cherry (A).
- After controlling for total leaf area and tree species, unbagged branches have approximately 13 less leaves than bagged branches, $p<0.05$ (B).
- After controlling for total leaf area and branch treatment, the tree species other than Black Cherry have approximately 354 less leaves than Black Cherry trees $p<0.0001$ (B). The wide confidence interval may reflect a need for a larger sample size.

Conclusions & Implications

After controlling for differences in the tree species, we see a significant decrease in the number of leaves on unbagged branches compared to bagged branches, contrary to my hypothesis.

While the main focus of this study has been on the damage that may be caused by an increase in the number of caterpillars on a tree, future studies can consider the response of the host tree itself. In the complex evolutionary history of plant-insect interactions, host plants have developed defenses against herbivory (reviewed by War et al. 2012).

Should we see a large decline in the number of leaves with an unchecked caterpillar population? The moment that an herbivore, such as our caterpillars, begin feeding on a plant, this induces a defensive response from the host plant similar to an immune system (reviewed by Fürstenberg-Hägg et al. 2013). These defensive mechanisms may help prevent an accumulation of leaf loss on trees hosting caterpillars.

Limitations

- This study looked across many different tree species, with varying characteristics.
- As we noted with Black Cherry trees, we must consider the variation between these trees as we collect data.
- This may provide different results in a trophic cascade analysis.
- These results may not generalize to all tree species and are specific to this study.
- Larger sample size would be beneficial.

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Author's contact: sparker26@mail.csuchico.edu