Causes of Variation in Damage by Folivores: The Roles of Ecosystem Productivity and Habitat Complexity

Shrestha, S*. and Russell, L.

Department of Biological Sciences, Fairmount College of Liberal Arts and Sciences

Abstract. Understanding the causes of variation in herbivore damage to plants is very important in that crop loss can be reduced, and damage may be manipulated to limit population growth of invasive weed species. My research focuses on variation of damage by insects to leaf tissues of tall thistle (*Cirsium altissimum*) rosettes under differing levels of ecosystem productivity and habitat complexity. I address four specific questions in my research. First, does ecosystem productivity affect the amount of tissue loss to insect herbivory? Second, does habitat complexity, in terms of litter and local species richness, affect tissue loss to insect herbivory? Third, is there any interaction effect between ecosystem productivity and habitat complexity on plant tissue loss to insect herbivores? Fourth, do ecosystem productivity and habitat complexity affect the fresh biomass of insect carnivores and herbivores? At each of two sites four 40 m X 40 m plots were established for ecosystem productivity manipulations and subplots within the 40 m X 40 m plots are used for manipulations of habitat complexity. Nitrogen was added to experimentally increase ecosystem productivity and litter (dead plant parts that are lying down) and plant species richness were manipulated for habitat complexity. Preliminary results from the first year of field work showed that the mean (± standard error) proportions of leaves damaged severely (>50% leaf area damaged) in control plots were 0.06 ± 0.01 in May, 0.25±0.01 in August and 0.10±0.07 in October. In nitrogen addition plots mean proportions of leaves damaged severely were 0.04±0.01 in May, 0.22±0.04 in August and 0.06±0.01 in October. Although nitrogen addition increased plant standing crop by 16.7%, differences in proportion of leaves damaged severely between control and N-addition plots were not statistically significant at any of the three months. Statistical analysis of these data is on-going.

1. Introduction

Damage by insects may cause a great loss to economically important plants and can affect the functioning of whole ecosystems. Understanding causes of variation in damage done by insects to plants is challenging as the amount of damage a plant suffers may be influenced by both biotic and abiotic factors. Understanding causes of variation in insect damage to plants could be used to create ecological conditions in agricultural fields that maximize damage to exotic weed species (Guretzky and Louda, 1997) so that economic losses as a result of weeds competing with crops could be reduced. Different types of insects consume more food while feeding on food resources low in nitrogen than in high nitrogen content (Slansky and Feeny, 1977, Meyer, 2000). With such studies, the factors that increase or decrease folivory (herbivory on leaves) of tall thistle (*Cirsium altissimum*) rosette plants could be understood, including causes of spatial variation in damage between plants in different habitats and temporal variation in damage to the plants through the growing season.

My research focuses on variation of damage by insects to leaves of tall thistle rosettes under differing levels of ecosystem productivity and habitat complexity. I test four hypotheses in this research. First, the amount of leaf tissue loss to insect herbivores by tall thistle rosettes will increase with ecosystem productivity. Second, the damage to tall thistle rosettes increases with habitat complexity in terms of litter but decreases with species richness. Third, habitat complexity and ecosystem productivity interact with each other that means increasing both of them, damage will be more. Fourth, increasing ecosystem productivity and habitat complexity will increase insect biomass at all trophic levels.

2. Experiment, Results, Discussion, and Significance

I am using two sites for my experiments; one is the WSU Biology Field Station and the other is Pawnee Prairie. At each site, ecosystem productivity manipulations are being applied to four 40 m X 40 m plots and subplots within the 40 m X 40 m plots are being used for manipulations of habitat complexity. Nitrogen was added to experimentally increase ecosystem productivity. To examine effects of habitat complexity, I manipulated litter (dead plant parts that are lying down) abundance and local plant species richness. For the litter treatment, there were three levels viz., litter removal, litter addition and control. Each litter treatment was randomly assigned to 21 focal plants with 7 plants receiving each level of the litter treatment on each in each large plot. For the species richness treatment, there were two levels viz., reduced plant species richness within a 30 cm radius of the focal tall thistle rosette and controlled. Fourteen tall thistle rosettes per large plot received the species richness treatment with 7 plants receiving each treatment level. Five traits were measured for each focal plant - (1) root crown diameter, (2) rosette diameter, (3) total number of green leaves, (4) number of leaves damaged over >30% of their surface area, and (5) number of leaves damaged over >50% of their surface area. I collected these data three times during the growing season, first in May, second in July and the third in October.

To evaluate whether any differences in damage to tall thistle rosettes between experimental treatments were due to treatment effects on insect herbivore densities, I sampled insects within experimental plots using four different methods. These four methods were – (1) sweep-netting along three transects per 40 m X 40 m plot, (2) beating 4 adult tall thistles per 40 m X 40 m plot with a stick to dislodge insects onto a collecting sheet, (3) 10 pitfall traps per plot, each trap was set up within 30 cm of a focal rosette; 6 for litter treatment and 4 four species richness, and (4) 10 sticky pads per plot distributed in the same manner as the pitfall traps. To measure ecosystem productivity, height of the dominant vegetation was measured and living plant biomass was dried and weighed. To measure resource availability to plants experiencing the different combinations of experimental treatments, measurements of light and soil moisture were taken.

Preliminary results from the first year of field work showed seasonal variation in leaf tissue removal from tall thistle rosettes, with highest levels of removal in August. The mean (± standard error) proportions of leaves damaged severely (>50% leaf area damaged) in control plots were 0.06 ± 0.01 in May, 0.25±0.01 in August and 0.10±0.07 in October. In nitrogen addition plots mean proportions of leaves damaged severely were 0.04±0.01 in May, 0.22±0.04 in August and 0.06±0.01 in October. Mean proportion of leaves damaged severely in control (non-nitrogen addition) plots for tall thistle rosettes where surrounding litter was removed were, 0.04±0.02 in May, 0.29±0.05 in August, and 0.12±0.09 in October; for litter addition, 0.07±0.02 in May, 0.26±0.06 in August, and 0.12±0.06 in October; for control, 0.02±0.01 in May, 0.31±0.05 in August, and 0.12±0.05 in October. Mean proportion of leaves damaged severely in nitrogen plots for litter removal were, 0.04±0.02 in May, 0.28±0.05 in August, and 0.08±0.06 in October; for litter addition, 0.03±0.01 in May, 0.26±0.06 in August, and 0±0 in October; for control, 0.05±0.02 in May, 0.23±0.05 in August, and 0.05±0.02 in October. Mean proportion of leaves damaged severely in control (non-nitrogen addition) plots for tall thistle rosettes where surrounding plant species richness was reduced were, 0.05±0.02 in May, 0.2±0.05 in August, and 0.12±0.04 in October; for control, 0.09±0.02 in May, 0.21±0.02 in August, and 0.10±0.05 in October. Mean proportion of leaves damaged severely for species richness in nitrogen plots were, 0.03±0.01 in May, 0.19±0.05 in August, and 0.05±0.02 in October; for control, 0.03±0.02 in May, 0.17±0.05 in August, and 0.09±0.03 in October. Statistical analysis of effects of litter and species richness as well as interactions between litter X nitrogen and species richness X nitrogen are on-going.

3. Conclusions

Although nitrogen addition increased plant standing crop by 16.7%, differences in proportion of leaves damaged severely between control and N-addition plots were not statistically significant at any of the three months. I will repeat my experiments in 2008 to examine temporal variation in effects on herbivory.

4. Acknowledgements

This project is funded by NSF DEB 0532018. I would like to thank my advisor, Leland Russell, and committee members, Karen Brown, Hongsheng Cao, and Arthur Youngman, my colleagues, Machale Spencer, Matthew Jones, Lorna Harder, Jim Culhane, and all members of Biology Department.

References:

[1]Guretzky, J.A., and S.M. Louda. Evidence for natural biological control: Insects decrease survival and growth of a native thistle. Ecological Applications **7**: 1330-1340, 1997.

[2]Slansky, F. Jr., and P. Feeny. Stabilization of the rate of nitrogen accumulation by larvae of the cabbage butterfly on wild and cultivated food plants. Ecological Monographs **47**: 209-228, 1977.

[3]Meyer, G.A. Interactive effects of soil fertility and herbivory on *Brassica nigra*. OIKOS **88**: 433-441, 2000.