RESPONSES OF NEMATODES TO UNGULATE HERBIVORY ON BLUEBUNCH WHEATGRASS AND IDAHO FESCUE IN YELLOWSTONE NATIONAL PARK

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♦ INTRODUCTION

The effects of ungulate grazing on the Northern winter range of Yellowstone National Park has recently received considerable attention. Early interest in this topic centered around the question to cull or not to cull elk in the Park. However, as the concepts of "maintaining ecological processes" (Houston 1982) and "ecosystem management" (Keiter 1991) have gained acceptance in Park management, understanding the dynamics and interactions of a broader array of herbivores inhabiting the Park will become increasingly important. In 1990, we studied the responses of Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Agropyron spicatum*) and their associated nematode communities to ungulate herbivory.

♦ OBJECTIVES

1. Compare root and shoot biomass and nitrogen concentration of grazed and ungrazed Idaho fescue and bluebunch wheatgrass plants during the growing season.

2. Compare the density of phytophagous and microbial feeding nematodes between grazed and ungrazed plants of the same species.

♦ METHODS

Our study site was located in the upper portion of the northern winter range near Crystal Creek at an elevation of approximately 1900 m. We collected 6-10 randomly selected plants of bluebunch wheatgrass and Idaho fescue from outside and inside a large exclosure established in August of 1987 (Frank 1990:17). Plants were collected with a soil corer (diameter 4.8 cm, depth 10 cm) and kept cool while transported to the laboratory where they were refrigerated until processing. Aboveground biomass was clipped at 2 cm and standing dead and green biomass were separated. The soil cores were suspended in cold water and the suspension was sieved first to remove plant tissue (sieve #18) and then to remove nematodes (sieve #325). Roots were hand-sorted while suspended in water and crowns, including the aboveground biomass to 2 cm, were cut from the roots. Plant biomass was dried at 40 ° C for at least 48 hrs and weighed. Nitrogen content of roots, crowns and aboveground green biomass, was analyzed using standard macro-kjeldahl techniques. Four additional cores were collected, 2 within the large exclosure and 2 in grazed areas, to determine soil moisture.

Nematodes were extracted on Baermann funnels for 48 hrs (Christie and Perry 1951). Nematodes were counted and identified to trophic level in 2 1-ml subsamples of a 30-ml suspension as described by Smolik (1974). Numbers of nematodes were corrected for extraction efficiencies.

Differences in biomass of plant parts from different grazing treatments were tested using a Mann-Whitney U test. Logarithmic transformations of nematode counts provided normally distributed data. Differences in nitrogen concentration and nematode densities of grazed and ungrazed plants within a sampling period were tested using a t-test.

♦ RESULTS AND DISCUSSION

Standing dead litter of ungrazed plants was greater than grazed plants at the beginning of the growing season (Table 1), but this difference narrowed during the growing season as dead plant material from previous year's growth fragmented, decomposed, or was eaten by small herbivores. Aboveground green biomass of ungrazed plants was approximately 3-4 times greater than grazed plants in May (Table 1). By the end of the growing season current growth of grazed plants of both plant species equalled that of plants in the ungrazed areas. In fact, in September we detected an increase ($\alpha = 0.10$) in the total current growth (green plus dead biomass) of grazed bluebunch wheatgrass plants. Frank (1990) found that grazing stimulated aboveground primary production by 36% at the site in 1989, a year of average or above average precipitation.

Root biomass of both grass species was lowest in July during the boot and flowering stage (Table 1). In May, root biomass averaged 35% and 26% lower in grazed plants of bluebunch wheatgrass and Idaho fescue, respectively. These differences disappeared by early June in bluebunch wheatgrass but lingered into mid-July in Idaho fescue. By September root reserves were generally replenished.

Nitrogen concentration of green aboveground biomass was significantly greater in plants outside the exclosure than inside the exclosure in both months sampled (Table 1). However, N concentration of root biomass was similar in plants from inside and outside the exclosure.

Abundance of nematodes followed a bimodal distribution which was consistent with soil moisture content (Table 2). In May, bacterial feeding nematodes were significantly higher under plants of both species that were open to grazing than those not open to grazing. This difference persisted into June under Idaho fescue plants but not under bluebunch wheatgrass plants. Similarly, densities of phytophagous nematodes were higher under grazed plants than ungrazed plants and these differences persisted into June only under Idaho fescue plants.

Our results indicate that aboveground grazing by ungulates facilitates feeding by some belowground taxa. Seastedt et al. (1988) hypothesized that belowground herbivores may increase after moderate levels of aboveground grazing because root quality counteracts the absolute decline in root resources. We found no difference in root N between grazed and ungrazed plants but did not examine changes in other parameters such as soluble carbohydrates or secondary plant compounds. Damage to root tips also may stimulate lateral root growth which may support high densities of nematodes (Hogger 1972, Rebois and Johnson 1973, Torrey 1976).

The high densities of microbial feeding nematodes found under grazed plants in May (both species) and June (Idaho fescue only) appear to be related to root mortality or exudation rates, which provide a short-term source of C for microbes, a prey base for microbivorous nematodes. We suggest that increased microbial biomass and activity increased nitrogen mineralization. Subsequently, grazing by nematodes and protozoa release N from microbial biomass that would otherwise become inaccessible to plants and aboveground herbivores.

♦ LITERATURE CITED

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Table 1. Biomass (g/dry matter/plant) of *Agropyron spicatum* and *Festuca idahoensis* plants inside and outside an exclosure on Crystal bench in Yellowstone National Park. Different letters indicate a significant difference between grazed and ungrazed plants at P<0.05.

	Agropyron spicatum				Festuca idahoensis			
	May	June	July	Sept	May	June	July	Sept
Standing dead								
Grazed	0.00[a]	0.02[a]	0.05[a]	0.06[a]	0.00[a]	0.01[a]	0.03[a]	0.10
Ungrazed	0.94[b]	0.26[b]	0.19[b]	0.45[b]	0.17[b]	0.04[b]	0.06[b]	0.24
Green biomass								
Grazed	0.23[a]	0.25[a]	1.51	1.79	0.20[a]	0.15	0.30	1.26
Ungrazed	0.94[b]	0.68[b]	1.53	0.68	0.85[b]	0.25	0.44	0.45
Crown Biomass								
Grazed	2.29	1.66	1.54	1.36	2.61	1.00	0.70	1.37
Ungrazed	3.14	1.37	1.26	1.28	3.02	1.11	0.94	1.03
Root Biomass								
Grazed	0.98[a]	1.05	0.92	1.90	1.02[a]	0.89[a]	0.68	1.62
Ungrazed	1.51[b]	0.97	0.83	1.81	1.38[b]	1.48[b]	0.91	1.00
Green Shoot N								
Grazed	2.46+	2.38			2.58[a]	1.74[a]		
Ungrazed	2.81	1.65			1.72[b]	1.33[b]		
Root N								
Grazed	0.93	1.39			1.06	1.16		
Ungrazed	1.22	1.14			1.01	1.16		

\+ indicates samples sizes were too small for analysis

Table 2. Densities of nematodes (No./g dry roots x 1000) below *Agropyron spicatum* and *Festuca idahoensis* plants from inside and outside a permanent exclosure on Crystal bench winter range in Yellowstone National Park. Different letters indicate a significant difference between grazed and ungrazed plants at P<0.05.

	Agropyron spicatum				Festuca idahoensis			
	May	June	July	Sept	May	June	July	Sept
Plant parasites								
Ungrazed	96[a]	105	58	52	76[a]	59[a]	34	77
Grazed	202[b]	100	42	56	346[b]	167[b]	37	59
Bacterial feeders								
Ungrazed	814[a]	488	285	354	856[a]	236[a]	205	420
Grazed	991[b]	285	249	281	1319[b]	539[b]	286	782

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