EFFECTS OF GRAZING AND MOWING ON LEYMUS CHINENSIS GRASSLAND IN THE SONGNEN PLAIN OF NORTHEASTERN CHINA

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ABSTRACT
Effects of mowing and grazing on a *Leymus chinensis* grassland in the Songnen plain of northeastern China were studied using eight replicates of four grazing and mowing treatments. Canopy cover and biomass of the dominant species (*L. chinensis*) were lower, and cover of the halophyte *Suaeda corniculata* higher, on grazed than ungrazed; ungrazed plots showed a response to mowing, but not grazing; species diversity increased with grazing and mowing. This study found dissimilar effects of grazing and mowing on plant populations, canopy biomass and structure in *L. chinensis* grassland. Possible interactions between the principal disturbances on the grassland are discussed.

KEYWORDS
Plant population, community structure, grazing, mowing, *Leymus chinensis* grassland

INTRODUCTION
The effects of various disturbances have been studied for many types of vegetation communities (Sousa, 1984, Li, 1993). Most studies have focused on changes in species composition, growth form, and canopy structure, and a few have examined relations between litter biomass and seed germination (Knapp and Seastedt 1986). Many of these studies dealt with grazing and fire; there is little information concerning the combined effects of mowing and grazing.

Grazing and mowing are the principal disturbances on the *Leymus chinensis* grassland of the Songnen Plain of northeastern China, limiting community succession and seed production (Li, 1978). The purpose of this research was to assess the effects of grazing and mowing on the grassland, and to investigate the main roles of interaction between these disturbances.

MATERIALS AND METHODS
Study site. The study area is located in the Yaojingzi Grassland Nature Reserve, Jilin province, P. R. China. The grassland is dominated by *Leymus chinensis* and is extensively grazed and mowed. It was grazed by cattle, horse and sheep, and mowed annually, for at least 20 years prior to 1991.

Climate. The area has a continental monsoonal climate, with large seasonal temperature variations. The annual precipitation ranges from 300-600 mm, with 60-70% of the total falling in mid-summer. A more detailed description of the climate of the region may be found in Ripley *et al*. (1996).

FIELD METHODS
Four treatments were used, each 50 ha in area, of which two were in a reserve fenced in 1991: (1) ungrazed + unmowed (-G-M), (2) ungrazed + mowed (-G+M); the other two were unfenced, (3) grazed + unmowed (+G-M); (4) grazed + mowed (+G+M). Between 1991 and 1995, the fenced area was protected from grazing, but mowing was carried out annually, in mid-August. Livestock (2.14 sheep unit/ha) grazed from early May until late October.

Vegetation was sampled from 8 randomly located 1 m x 1 m quadrats before mowing. Aerial cover of each species was estimated visually. Shoots were harvested close to the ground and oven-dried at 80°C before weighing. Litter was collected from each harvested quadrat and washed using flotation. The samples were placed in perforated paper bags, ovendried and weighed.

DATA ANALYSIS
Twenty-five plant species were found on the study site. The most abundant: *Leymus chinensis, Carex duriuscula, Potentilla flagellaris, Chloris vergata, Suaeda corniculata* and *Setaria viridis,* accounted for over 80% of the plant cover (Table 1). Species were categorised by growth form, as (1) perennial grasses, (2) annual grasses, (3) non-halophytic forbs, or (4) halophytic forbs.

Species diversity was calculated as a function of species density (Barbour *et al*., 1987) and evenness from diversity and total number of species (Pielou, 1975). A one-way analysis of variance was used to determine the significance of grazing and mowing on plant population, canopy biomass, litter biomass, and species diversity.

RESULTS
Plant population. Grazing and mowing had significant effects on species cover (Table 1). As disturbance increased, the cover of *Leymus chinensis* dropped. Even though covers of *L. chinensis* did not differ between two grazed treatments, they were lower than -G+M. Cover of Chloris vergata was higher on -G+M and on grazed treatments than on -G-M, but did not differ between the grazed treatments.

Cover of legumes decreased with disturbance, few being found on grazed treatments. Covers of most forbs were higher on -G+M and +G-M, and lower on undisturbed and +G+M. The covers of *Suaeda corniculata* were higher on grazed treatments than on -G-M, and higher than that on -G+M.

Canopy and litter biomass. Canopy biomass was significantly ($P < 0.05$) lower on grazed treatments and lower on +G-M than -G+M (Table 2); although grazed treatments did not differ from each other. Fractional biomass of grasses was lower on grazed than on -G-M, but there was no difference between the grazed treatments.

Litter biomass was highest on -G-M, and was reduced by grazing and mowing. It was lower on -G+M and +G+M than on +G-M.

Growth form. Numbers of perennial grass species did not differ between the two ungrazed treatments or the two grazed treatments, but were lower on grazed than -G+M (Table 2). Numbers of annual grass species were not significantly different among -G+M, +G-M and +G+M, but were lowest on -G-M. Numbers of forb species increased with disturbance, were highest on +G-M, and decreased on +G+M. Numbers of halophyte species also increased with disturbance, being higher on the grazed treatments than on -G-M, and differing between -G+M and +G-M, but not between the two grazed treatments.

Canopy structure. Both indices of diversity differed between grazing and mowing (Table 2). Shannon's index was lowest on -G-M, but there was no difference between the other treatments. Evenness increased with disturbance, being highest on +G+M, but there was no difference between -G+M and +G-M.

DISCUSSION

Grazing had greater effects than mowing on species numbers, canopy biomass and biomass fraction of grasses in the canopy. Canopy cover of *Leymus chinensis* on grazed treatments was one-third that of undisturbed, compared with one-half on mowed treatments; covers of *Chloris vergata* and *Suaeda corniculata* were greater on grazed.

Litter reduced species diversity in the undisturbed treatment. In the grazed treatments, especially in overgrazed areas, litter: maintained soil water by reducing evaporation, reduced soil pH and increased soil organic matter (Guo, 1990, Wang and Li, 1995). This may permit invasion and establishment in areas with well-developed litter.

Numbers and covers of perennial grasses and legumes decreased with increase in disturbance, while those of annual grasses and halophytes increased. Halophytes, especially *Suaeda corniculata*, became dominant on +G-M and +G+M.

Species diversity and evenness were lowest on the undisturbed plots; increasing at first with disturbance, but dropping again in +G+M; no difference was found between -G+M and +G-M.

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REFERENCES

Barbour, M.G., J.H. Burk and W.D. Pitts. 1987. Terrestrial Plant Ecology, (2nd ed.). Benjamin/Cummings Inc., New York.

Guo J.X. 1990. Preliminary study on the formation of litter in *Leymus chinensis* grassland. Journal of Ecology (China) **9** (1): 11-14.

Knapp, A.M. and T.R. Seastedt. 1986. Detritus accumulation limits productivity of tallgrass prairie. Bioscience **36**: 662-668.

Li J.D. 1978. *Aneurolepidium chinense* grassland in China. Journal of Northeast Normal University **1**: 145-159.

Li Y.H. 1993. Grazing dynamics of species diversity in *Aneurolepidium chinense* steppe and Stipa grandis steppe. Acta Botanica Sinica **35** (1): 877-884.

Pielou, E.C. 1975. Ecological Diversity. Wiley, New York.

Ripley, E.A., R.Z. Wang and T.C. Zhu. 1996. The climate of the Songnen Plain, northeast China. International Journal of Ecology and Environmental Science **22**: 1-19.

Sousa, W.P. 1984. The role of disturbance in natural community. Annual Review of Ecology and Systematics **15**: 353-392.

Wang R.Z. and Li J.D. 1995. Grazing succession pattern of alkalised *Aneurolepidium chinense* grassland in Songnen plain. Chinese Journal of Applied Ecology **6** (3): 277-281.

Table 1

Canopy covers (%) of plant species classified by growth form on four treatments in the Leymus chinensis grassland. A superscript indicates that the value differs significantly from -G-M at the: 15%, 21%, or 30.1% level.

Species	Treatments			
	-G-M	-G+M	+G-M	+G+M
Perennial grasses				
Leymus chinensis	63.8	34.4[3]	20.1[3]	21.3[3]
Aeluropus litoralis	0.7	6.3[2]	4.8	2.61
Cleistogenes squarrosa	0.1	0.1	1.2[2]	0.1
Calamagrostis epigeios	0.6	0.1[1]	02	0[2]
Carex duriuscula	5.7	4.4[2]	6.5[2]	7.1[3]
Annual grasses				
Setaria viridis	0.1	0.3[1]	1.8[3]	2.9[3]
Echinochloa crusgalli	0.1	1.0	1.81	0.1
Eragrostis pilosa	0	0.9[1]	0.1	0.1
Chloris vergata	0.1	0.6[2]	9.9[3]	10.0[3]
Non-halophytic forbs				
Artemisia scoparia	0	0	0.1	0.5
Kalimeris integrifolia	0.1	0.8[1]	0.7[1]	0.1
Medicago falcata	1.3	0.5	0.33	03
Lespedeza davurica	1.3	0.1[1]	03	03
Potentilla flagellaris	0.3	2.1[3]	6.6[3]	6.4[3]
Plantago depressa	0	0	0.5[1]	0.3[1]
Taraxacum erythropodium	0	0	0.3	0.3
Halophytic forbs				
Sueda corniculata	0.1	0.7	28.3[3]	26.8[3]
Artemisia anethifolia	0	0.1	0.1	0.1

Table 2

Canopy and litter biomass, species numbers and diversity indices for the four grazing and mowing treatments in the Leymus chinensis grassland. Values with the same superscript letters do not differ significantly at $p < 0.05$.

Vegetation characteristics	Treatments			
	-G-M	-G+M	+G-M	+G+M
Canopy and litter biomass				
shoot biomass (g m-2)	423	265	164a	161[a]
grass biomass fraction	0.92[b]	0.94[b]	0.57[c]	0.59[c]
litter biomass (g m-2)	273	38	89	32
Species numbers				
perennial grasses	5[d]	5[d]	4[e]	4[e]
annual grasses	3	4[f]	4[f]	4[f]
non-halophytic forbs	6	7	11	9
halophytic forbs	2	3	5[g]	5[g]
Species diversity				
Shannon's diversity index	0.49	0.87[h]	0.88[h]	0.82[h]
Pielou's evenness index	0.35	0.48i	0.47[i]	0.56