Differences in plant communities and soil properties in grazed versus mown lands around Xilinhot, Inner Mongolia

Li Q., Mochida Y., Fujiwara K.

Graduate School of Environment and Information Sciences, Yokohama National University, Tokiwadai 79-7, Hodogaya-ku, Yokohama 240-8501, Japan
Graduate School in Nanobioscience, Yokohama City University, Seto 22-2, Kanazawa-ku, Yokohama City, 236-0027, Japan

Abstract

A *Carex duriuscula-Stipa krglovii* community and a *Serratula centauroides-Stipa grandis* community were classified, based on Braun-Blanquet methodology, in grazed versus mown areas, respectively. In the 0~10cm soil layer, soil compaction and water content were significantly different in the grazed and mown sites; at 11~30cm, soil temperature was significantly higher at grazed sites than at mown sites. The species dominating on grazed sites were more closely related to compacted soil, higher soil temperature and lower water content, whereas the species dominating on mown sites were more closely related to the opposite environmental conditions.

Keywords: grazing, mowing, plant community, soil property, Inner Mongolia

Introduction

Grassland is a major terrestrial ecological system (Xu *et al*. 2008), and the grassland around Xilinhot is a very important part of Inner Mongolia (northern People's Republic of China) (Li *et al*. 2008). It is also the critical resource that supports livestock and performs the important function of stabilizing the soil. Moderate grazing is a major management form in temperate grasslands (Bullock *et al*. 2001), and mowing for animal fodder is another main use of grassland (Wang *et al*. 2007). The main uses of the grassland around Xilinhot are also grazing and mowing. Much research has attempted to assess, separately, the effects of grazing, mowing and enclosures on the grassland communities. There has been less research, however, comparing the effects of grazing and mowing on the grassland communities and on soil properties.

In order to find the most rational use of grassland at a place, it is necessary to compare the effects of grazing and cutting systems. Therefore, the objects of this study are: (1) to compare the differences in plant species composition under grazing and mowing regimes; (2) to compare the soil properties under grazing and mowing; and (3) to identify relationships between species composition and soil properties.

Material and methods

The study area is located around Xilinhot city (43°02′～44°52′N, 115°13′～117°03′E), which is located in the central part of the Xilingol grassland, the typical steppe of Inner Mongolia. Xilinhot has a semi-arid temperate continental climate (Lu *et al*., 2004), with long, cold winters and short, cool summers. The mean annual temperature is -1.4, and average annual precipitation is 250-350mm, falling mainly from June to August. The mean annual evaporation is 1746 mm, which is six times the annual precipitation. The average elevation is about 988m.

The study was conducted at three sites (Maodeng, Huitengliang and Bayannaoer) around Xilinhot city, all of which have both grazing land and mowing land adjacently. At Maodeng and Huitengliang the lands were mown from the 1970's but at Bayannaoer only from 2005. A vegetation survey was performed in the summers of 2009 and 2010. At each site, 20 relevés were recorded by the Braun-Blanquet phytosociology method (Braun-Blanquet 1964, Fujiwara 1997). 10 relevés represent grazing land and 10 relevés represent mown land. On the three plots at each site where the vegetation survey was done, we also took soil samples in three layers (0~10cm, 11~20cm and 21~30cm). The soil properties recorded were pH, water content (WC), electrical conductivity (EC), compaction and temperature.

The plant communities were also classified by Braun-Blanquet methodology. Using SPSS 11.5 we conducted t-tests on independent samples to analyze threshold levels for the effects of grazing and mowing on plant height, plant cover, species richness and soil properties. A redundancy analysis (RDA) in CANOCO for Windows 4.5 (Jongman *et al.* 1995) was used to analyze relationships between species composition and soil properties.

Result

Species composition and plant communities

In this study 77 vascular plant species were identified, of which 42 were found in grazing lands and 65 in mown lands. Two communities were classified by Braun-Blanquet methodology, namely a *Carex duriuscula-Stipa krglovii* community and a *Serratula centauroides-Stipa grandis* community.

The *Carex duriuscula-Stipa krglovii* community occurs mainly in grazing areas of the three sites. The mean plant height of this community is 9.5cm, its mean plant cover is 30%, and the mean number of species present (species richness) is 12 (Table 1). This community can be divided further into three sub-types: a typical sub-type at Huitengliang, a *Convolvulus ammannii* sub-type at Bayannaoer, and a *Chloris virgata* sub-type at Maodeng. The typical sub-type is shortest in stature and has the lowest average plant cover and fewest species; the *Convolvulus ammannii* sub-type is the tallest and has the highest average plant height and number of species (Table 1).

Table 1. Plant height, cover and species richness at three sites in Xilinhot

location	usage	height	cover	richness
		cm	%	
Maodeng	Grazing	9.4±4.2a	31.0±5.2a	10.3±2.0
	Mowing	77.0±23.6b	55.5±7.2b	11.5±2.5
Huitengliang	Grazing	9.2±1.0a	28.0±2.6a	9.0±1.1a
	Mowing	40.8±4.3b	61.0±6.1b	29.6±1.5b
Bayannaoer	Grazing	9.8±1.5a	30.0±4.1a	15.9±1.7
	Mowing	22.0±3.2b	46.0±6.1b	14.7±2.6
All	Grazing	9.5±2.6a	29.7±4.1a	11.7±3.4a
	Mowing	46.6±26.8b	54.2±8.9b	18.6±8.3b

Within columns,means±S.D. with the different letters are significantly different (p<0.001).n=10

The *Serratula centauroides-Stipa grandis* community occurs mainly on mown areas of the three sites. The mean plant height of this community is 46.6cm, its mean plant cover is 54%, and the mean number of species is 19 (Table 1). This community can be divided into two sub-types a *Chenopodium aristatum* sub-type occurring at Maodeng and an *Agropyron cristatum* sub-type occurring at Huitengliang and Bayannaoer. The *Chenopodium aristatum* sub-type is taller but has fewer species. The *Agropyron cristatum* sub-type can be divided further into two sub-units, a *Poa attenuata* sub-unit occurring at Huitengliang and an *Artemisia scoparia* sub-unit occurring at Bayannaoer.

The mean plant height at the three sites was significantly higher on mown land than on grazed land, as was the mean plant cover. The mean number of species was significantly higher on mown land only at Huitengliang, and there was not a statistically significant difference between grazed and mown land at the other two sites (Table 1).

Soil properties. The result of soil properties are given in Table 2. Significant differences for soil compaction (p=0.006) and soil water content (p=0.040) were detected in the 0~10cm layer between grazed and mown land. Significantly different soil temperature was also detected in the 11~30cm layer. Soil electrical conductivity was higher on grazed land in each layer at all three sites, but it was not significantly different. Soil pH was statistically and numerically similar at all three sites.

Table 2. Soil properities of three layers at three sites in Xilinhot

	usage	Compaction	Temp.	WC	EC	pH
		mm	℃	%	ms /m	
0-10cm	Grazing	26.3±2.0a	28.2±1.4	10.1±3.3a	4.3±1.9	8.1±0.5
	Mowing	21.9±3.6b	27.2±1.2	13.2±2.5b	3.3±1.9	7.9±0.3
11-20cm	Grazing	26.8±2.8	25.1±1.3a	11.9±4.5	4.8±3.1	8.3±0.4
	Mowing	24.6±5.3	22.9±1.4b	13.9±4.0	4.0±2.8	8.1±0.3
21-30cm	Grazing	27.3±2.1	24.3±1.5a	12.4±5.8	7.9±6.6	8.5±0.4
	Mowing	28.6±3.9	22.3±1.3b	10.8±3.4	4.0±3.0	8.2±0.4

Within columns,means±S.D. with the different letters are significantly different ($p<0.05$),n=3

Ordination. The ordination (Fig.1) shows a clear relationship between species composition and soil properties in the 0~10cm layer. The main species on grazing sites at Maodeng were likely to appear in high pH and high electrical conductivity. The other species dominant on grazing sites were likely to appear in compacted soil and higher soil temperature and lower water content. The species dominant on mown sites were likely to appear under the opposite environmental conditions.

Conclusion

In this study different land uses differentiated two communities, both of which could be subdivided into sub-types at different sites. The main species in the sub-types on grazed land were annual plants, whereas under mowing they were perennial plants. Grazing has a much heavier effect on plant height and cover than mowing.

The soil in the 0~10cm layer was significantly compacted and soil water content in it was significantly lower on grazed sites than on mown sites. At 11~30cm soil temperature was significantly higher under grazing than under mowing.

The species dominating on grazed sites were more closely related to compacted soil, higher soil temperature and lower water content, whereas the main species on mown sites were more closely related with the opposite environmental conditions.

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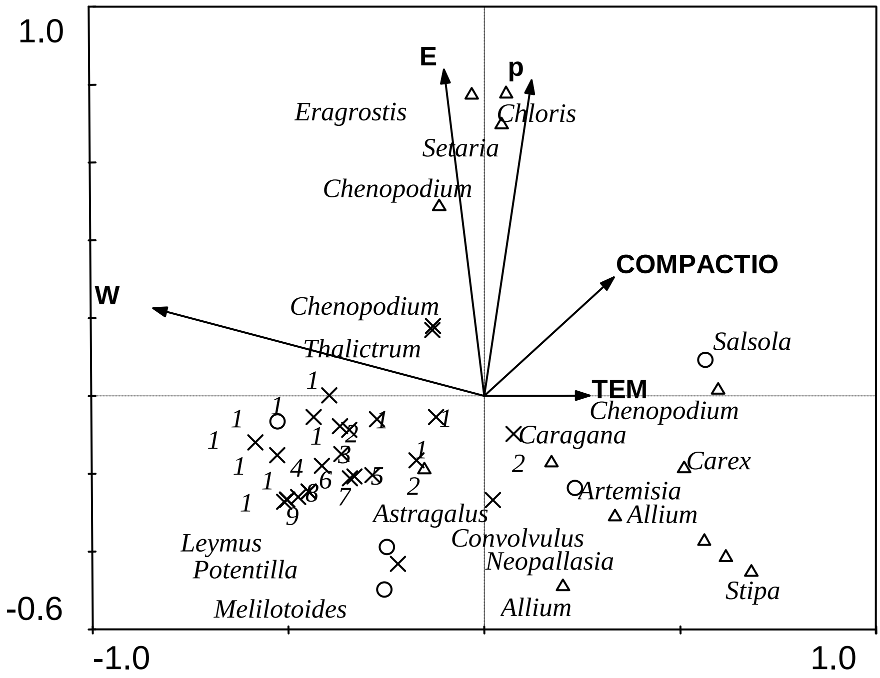

Fig.1 Results of RDA Ordination for species composition versus soil properties of the 0~10cm layer of three sites of Xilinhot City. Δ represents species favored by grazing, × represents species favored by mowing and ○ represents common species. 1 *Koelrria cristata*, 2 *Saposhnikovia divaricata*, 3 *Potentilla longifolia*, 4 *Adenophora stenanthina*, 5 *Cymbaria dahulica*, 6 *Galium verum*, 7 *Spiraea aquilegifolia*, 8 *Dontostemon integrifolius*, 9 *Allium senescens*, 10 *poa attenuate*, 11 *Carex korshinskyi*, *Achnatherum sibiricum*, *Scorzonera austriaca*, *Buplurum scorzonerifolium*, *Agropyron cristatum*, *Schizonepeta multifida*, *Potentilla tanacetifolia*, *Artemisia oxycephala*, 12 *Allium condensatum*, 13 *Stipa grandis*, 14 *Cleistogenes squarrosa*, 15 *Thalictrum petaloideum*, 16 *Serratula centauroides*, 17 *Artemisia scoparia*, 18 *Asparagus dauricus*, 19 *Allium anisopodium*, 20 *Lepidium apetalum*, 21 *Heteropapus altaicus*.

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