YIELDS AND DOMINANCES OF MICRO-VEGETATION IN FOREST-STEPPE PASTURE NEARBY A POPULATION CENTER OF MONGOLIA

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ABSTRACT

A study was conducted in 2011 and 2012 on a forest-steppe pasture in danger of pasture degradation to determine pasture yields and plant dominances from differences in micro-vegetation, with the aim of contributing to conservation and effective utilization. In the pastures, two different micro-vegetation located conterminously were observed based on their topographies and coverage by dominant plant species: Site 1 (S1) on a hillside where Poa or grasses and herbs equally dominated and Site 2 (S2) in a pocket where herbs predominated followed by Poa or grasses. Yield was significantly increased from June to August, but decreased by October in both the sites in each year ($p < 0.001$). The yields in S2 were significantly ($p < 0.001$) or tended to be higher than those in S1 during all study periods. The relative summed dominance ratio (R-SDR2) of the grass was higher in S2 (34.0%) than in S1 (18.4%), and that of herbs was higher in S1 (64.2%) than in S2 (51.8%). It was concluded that R-SDR2 is a potential indicator of pasture condition, and that the proportion of grasses increase while that of herbs decrease as a pasture is well conserved and/or managed.

KEY WORDS: coverage, nutrient gradient, pasture degradation, plant biomass, SDR2

INTRODUCTION

Monitoring pasture condition is very important in Mongolia, considering most of the animals in the country are grazed by herders in open natural pastures throughout the year, and their condition is reflected directly in animal production. Although pastures provide approximately 90% of their annual nutritional requirement, the animals suffer continuously from changes in environmental conditions, such as changes in nutritional value of pasture plants [5, 6]. The socio-economic environment, such as the reform that went into effect in the late 1980s, has also increased anxiety for pasture degradation, and this anxiety has been continued until now [4]. In addition, as the herders graze their animals in local pastures, they need to know the differences in the micro-vegetation in the pastures for its optimal conservation and use. Therefore, the importance of monitoring micro-vegetation is increasing, particularly nearby population centers. However, reported information on differences in micro-vegetation is rare, particularly with respect to the dominance relationships of pasture plants [7]. We accordingly conducted a study to determine the

pasture yields and plant dominances based on differences in micro-vegetation in pastures, and to identify reliable indicators of pasture condition.

MATERIALS AND METHODS

Sites: An open natural pasture (N 47°52'10,9"; E 106°08'52,1") at Argalant rural district of Tuv Prefecture, 70 km west of Ulaanbaatar, the capital of the country, with an area greater than 10 ha, was selected for the study. The pasture was used for grazing during cold seasons and less used during the study period, June and October. The vegetation type of the area is classified into forest–steppe. In the pasture, two different micro-vegetations located conterminously were observed based on their topographies and coverage (C) by the dominant plant species: Site 1 (S1) on a hillside where Poa or grasses and herbs equally dominated, and Site 2 (S2) in a pocket where herbs were predominant followed by Poa or grasses.

Yields: Yields of the sites were determined five times at the end of June and in early October in both 2011 and 2012. Ten to 30 spots representing the vegetation at each site were selected, and in each spot all aboveground parts of plants growing within a circle with a diameter of 0.6 m were cut. The cut herbage was dried at 60C for at least 24 h in an air-drying oven and then left at room temperature for 4 h, after which the weight of dry matter (DM) was determined.

Vegetation: A survey was performed at each site in August 2011 and 2012, when the yields were approximately highest and it was easiest to identify the plants [12]. The C and height (H) of plants appearing in a 1 m2 quadrat, with 30 replications at each site, were determined using a Ramenskii cage [10]. The plant species were identified following Ulziikhutag [13]. Plants were classified according to their families and genera into five groups: grass, legume, Carex, Artemisia, and herbs, or groups 1–5.

The summed dominance ratio (SDR has been used to characterize species dominance in grassland community studies [8]. The SDR2 for a given species is defined as the average of the following two quantities:

$$SDR2 = (C' + H') / 2$$

where C' and H' are the C and H of each species relative to the maximum values in one community, and the subscript indicates the number of parameters used for the formula.

Thus, the SDR2 takes values between 100 and 0. To compare the vegetation among various communities, the relative SDR (R-SDR2) was calculated as follows [14]:

$$R\text{-}SDR2 = SDR2 / \text{summed } SDR2 * 100$$

where SDR2 describes the dominance of each species or plant group and the summed SDR2 is the summed dominance of all plant species or groups in one community.

Statistical analysis: Yield data were analyzed in a two-factor design by ANOVA using a general linear model with Minitab release 16 (MINITAB Inc.) to identify differences by the site and sampling time and their interactions [9]. Where interactions were significant, the differences between the means were compared by the Tukey's test at the 5% level.

RESULTS

Yields: The results of the two-factorial design by ANOVA showed a significant ($p < 0.001$) interaction between the sites and survey times. Then, the differences between the means were compared (Table 1). The yield significantly increased from June to August, but decreased by October at both sites in each year ($p < 0.001$). The yields in S2 were significantly ($p < 0.001$) or tended to be higher than those in S1 during the study period. Some differences were found in each site between years: in S1, yield was significantly ($p < 0.001$) or tended to be higher in 2011 than in 2012 in the surveyed period, and in S2, it was almost identical in June and July but was lower in 2012 than in 2011 in August and October.

Table 1

Yields of studied pasture sites determined five times at the end of June and in early October in 2011 and 2012

Site[1)]	Year	Time					SEM[2)]	p[3)]
		Jun.	Jul.	Aug.	Sep.	Oct.		
S1	2011	1,047.9 c, B	1,433.7 ab, B	1,574.5 a, C	1,398.6 abc, BC	1,175.5 bc, B	77.9	***
	2012	902.2 c, B	1,148.0 b, C	1,383.6 a, C	875.4 bc, C	559.1 bc, C	93.1	***
S2	2011	1,913.3 b, A	2,477.3 b, A	3,489.2 a, A	2,260.2 b, A	1,861.9 b, A	185.2	***
	2012	2,003.0 bc, A	2,414.0 b, A	3,036.2 a, B	1,745.0 bc, B	1,106.7 c, B	167.6	***
SEM		153.2	93.7	112.4	137.8	119.0		
p		***	***	***	***	***		

[1)] Site: S1; a pasture site on a hillside where Poa or grasses and herb equally dominated, S2; a pasture site in a pocket where herb were predominant followed by Poa or grasses. The both sites located conterminously each other (N47°52'10,9"; E106°08'52,1") in Argalant rural district of Tuv prefecture.

[2)] SEM; pooled standard error mean,

[3)] ***; $p < 0.001$, [a, b, c]; Means within the same row with different superscripts are significantly different, and [A, B, C]; Means within the same column with different superscripts are significantly different by the Tukey's test at the 5% level, respectively.

Vegetation: Numbers of genera and species appearing in the studied sites are shown in Table 2. A total of 67 genera and 80 species were recorded in S1 and S2; 30 genera and 50 species in S1, and 34 genera and 39 species in S2. Only 7 genera and 9 species appeared in both sites. In both S1 and S2, two thirds of the genera and species belonged to group 5, or herbs. The differences between the two sites in the number of herbaceous genera and species reflected the differences in total numbers.

Table 2

Means of families, genera and species appeared in the studied pasture sites in August 2011 and 2012

	S1[1)]		S2		S1 & S2	
	Genera	Species	Genera	Species	Genera	Species
Group 1: Poa/grass	6	6	6	8	10	12
Group 2: Legum	4	5	3	4	7	9
Group 3: Carex	1	2	1	1	1	2
Group 4: Alluim	1	2	1	1	1	3
Group 5: Herb	27	35	23	25	48	54
Total	39	50	34	39	67	80

[1)] See, Table 1.

Table 3 shows the average C, H, and dominance of each plant appearing in the studied sites in August of 2011 and 2012. The results show that both studied sites were mixed pastures in which some or many plants were growing, and that no plant dominated strongly. For example, in S1 the C and R-SDR2 were highest for Stipa krylovii (25.0% and 8.0%, respectively) and next highest were for Artemisia frigida (15.0% and 3.4%, respectively). In contrast, the Cs of grasses and herbs were 36.4% and 35.3% in S1 and 26.0%

and 57.6% in S2, respectively, and the Cs of these two plant groups comprised 89.7% and 87.3% of the whole C of each pasture. The following tendencies were found: C was higher in S2 (95.8%) than in S1 (79.9%); Hs of all plants appearing in both sites, such as Agropyron cristatum and Artemisia dracaunculus, were higher in S2 than in S1; the R-SDR2 of grasses was higher in S2 (34.0%) than in S1 (18.4%), and that of herbs was higher in S1 (64.2%) than in S2 (51.8%).

Table 3

The average coverage (C), height (H) and dominance of the each plant appearing in the studies pasture sites in August in 2011 and 2012

Plants	C, %		H, cm		SDR_2[1)]		R-SDR_2[1)]	
	S1	S2	S1	S2	S1	S2	S1	S2
Group 1: Poa/grass								
Agropyron cristatum	1.0	1.0	29.0	45.2	48.1	38.6	4.6	3.9
Bromus inermis		6.0		38.0		42.4		4.2
Cleistogenes squarrosa	4.0		4.6		12.9		1.2	
Elymus dahuricus		11.0		37.5		51.6		5.2
Elymus Gmelinii		5.0		50.0		50.3		5.0
Festuca lenensis	0.4		10.1		16.8		1.6	
Hordeum brevisubulatum		0.5		61.5		51.0		5.1
Koeleria macrantha	1.0		6.6		12.1		1.1	
Leymus chinensis	5.0		7.7		19.3		1.8	
Poa attenuata		0.5		27.5		23.3		2.3
Stipa Krylovii	25.0	1.0	31.0	52.5	84.3	44.6	8.0	4.5
Stipa Sibirica		1.0		45.0		38.5		3.8
Sub-total	36.4	26.0			193.5	340.4	18.4	34.0
Group 2: Legum								
Astragalus scaberrimus	0.5		7.6		13.0		1.2	
Caragana microphylla	0.5		15.4		25.5		2.4	
Caragana pygmaea	0.3		23.0		37.5		3.6	
Hedysarum collinum	0.2		3.8		6.5		0.6	
Oxytropis filiformis	0.1		5.0		8.2		0.8	
Sanguisorba officinalis		3.0		60.0		54.5		5.4
Thermopsis dahurica		0.1		11.0		9.1		0.9
Vicia amoena		2.0		15.3		16.2		1.6
Vicia multicaulis		2.0		26.6		25.5		2.5
Sub-total	1.6	7.1			90.6	105.4	8.6	10.5
Group 3: Carex								
Carex duriuscula	5.0		9.5		22.2		2.1	
Carex pediformis	1.0	5.0	13.0	15.1	22.3	21.9	2.1	2.2
Sub-total	6.0	5.0			44.5	21.9	4.2	2.2
Group 4: Alluim								
Allium odorum		0.1		18.0		14.8		1.5
Allium bidentatum	0.5		13.0		21.6		2.1	
Allium teniussimum	0.1		16.0		25.9		2.5	
Sub-total	0.6	0.1			47.5	14.8	4.5	1.5
Group 5: Herb								
Amblynotus rupestris	0.3		5.0		8.5		0.8	
Arenaria cappilarris	0.7		9.0		15.4		1.5	
Artemisia Adamsii	3.0		13.1		25.2		2.4	
Artemisia dracaunculus	3.0	13.0	21.3	24.8	38.4	45.2	3.7	4.5

Artemisia Gmelinii	3.0		16.2		30.2		2.9	
Artemisia frigida	15.0		9.4		35.8		3.4	
Artemisia lacinata		4.0		7.1		13.5		1.3
Phlomis tuberose		11.0		25.0		41.5		4.1
Linium baicalense		1.0		17.5		16.2		1.6
Lilium tenufolium		1.0		25.5		22.7		2.3
Aster alpinus	0.5	1.0	12.1	25.5	20.1	22.7	1.9	2.3
Aconitum barbatum		7.0		18.5		28.5		2.8
Adenophora Stenanthina		0.1		18.0		14.8		1.5
Androsace incana		0.1		15.0		12.4		1.2
Bupleurum scorzonerifolium	0.5		10.8		18.0		1.7	
Carum carvi		1.8		23.5		22.5		2.2
Campanula glomerata		0.2		24.4		20.2		2.0
Chamaerhodos erecta	0.1		16.0		25.9		2.5	
Cymbaria dahurica	0.4		5.5		9.4		0.9	
Delphinium Triste		5.0		13.0		20.2		2.0
Dendrontemon Zawadskii		1.0		8.7		9.0		0.9
Dontostemon integrifolius	0.4		11.0		18.3		1.7	
Erysimum flavum		0.1		28.0		23.0		2.3
Euphorbia discolor	0.1		11.0		17.9		1.7	
Gentiana macrophylla	0.1		13.0		21.1		2.0	
Goniolimon speciosum	0.3		10.0		16.5		1.6	
Haplophyllum dahuricum	0.5		14.2		23.4		2.2	
Iris tigridia	0.1		11.9		19.3		1.8	
Leontopodium leontopodoides	0.5		11.3		18.8		1.8	
Myosotis Asiatica		0.1		12.0		9.9		1.0
Orostachys spinosa	0.1		4.1		6.7		0.6	
Panzeria lanata	0.3		16.0		26.2		2.5	
Pedicularis flava	0.2		16.3		26.5		2.5	
Polygonum angustifolium		3.0		28.0		28.5		2.8
Polygonum aviculare	0.2		17.0		27.7		2.6	
Potentilla acaulis	1.3		2.0		4.9		0.5	
Potentilla bifurca	0.2		8.0		13.2		1.3	
Potentilla conferta	0.1		10.0		16.3		1.6	
Potentilla strigosa	0.2	2.0	9.0	16.5	14.8	17.3	1.4	1.7
Potentilla tanacetifolia	0.6		9.1		15.5		1.5	
Potentilla verticillaris	0.1		2.4		4.0		0.4	
Ptilotrichum canescens	0.3		7.9		13.1		1.2	
Pulsatilla Turczaninovii		0.5		9.0		8.3		0.8
Rheum undulatum	0.6	1.0	13.0	15.0	21.8	14.0	2.1	1.4
Saussurea salicifolia	1.0		6.9		12.4		1.2	
Schizonepeta multifida	0.2		15.0		24.5		2.3	
Senecio campester		0.1		23.0		18.9		1.9
Serratula centauroides	0.2	0.9	12.0	32.1	19.6	27.8	1.9	2.8
Sibbaldianthe adpressa	0.1		9.5		15.5		1.5	
Silene repens	0.2	0.2	15.8	34.0	25.7	28.0	2.4	2.8
Stellera chamaejasme	1.0		13.2		22.6		2.2	

Schizonepeta longifolia		0.1	18.0		14.8		1.5
Thalictrum minus		1.5	18.5		17.8		1.8
Thalictrum foetidium		2.0	21.6		21.4		2.1
Sub-total	35.3	57.6		673.3	518.9	64.2	51.8
Total	79.9	95.8		1,049.4	1,001.4	100.0	100.0

[1)] SDR: summed dominance ratio. $SDR_2 = (C'+H') / 2$, where C′ and H′ are the C and H of each species relative to the maximum values in one community, and the subscript indicates the number of parameters used for the formula.

[2)] $R\text{-}SDR_2 = SDR_2 / \text{summed } SDR_2 * 100$, where SDR_2 describes the dominance of each species or plant group and the summed SDR_2 is the summed dominance of all plant species or groups in one community.

DISCUSSION

The results for yields and their seasonal changes were in agreement with previous studies, and the yields were greater than those in pastures using for grazing and nearly equal to those in well conserved pastures [1 - 3, 11, 15 - 17]. Yields were significantly or tended to be greater in S2 than in S1. The difference was not caused by grazing, given that the two sites were located conterminously and no fence had been constructed around or between them. This difference would be caused by micro-methodological or topographical differences, such as the rainfall on the pasture that had run from S1 or the hillside to S2 or the pocket, and the supply of water in the S2 accelerated the growth of plants in the semi-arid regions where water supply is usually a limiting factor for plant growth. The water supply may account for the increased numbers of genera and species in S2 and the higher C in S2 (95.8%) than in S1 (79.9%).

Zolzaya et al. (2013) studied the pastures located in the same rural district and having the same vegetation type as those in the present study [17]. Their results showed that number of genera and species differed according to its distance from a water source. The numbers increased with distance, or when the pasture was less degraded, up to 20 genera and 31 species in a pasture 10 km away. The numbers in the present study were 39 and 34 genera and 50 and 39 species in S1 and S2, respectively, and were greater than those in the previous study. These results suggest that the pasture in the present study was less degraded or better conserved than that in the previous one. The restricted grazing during the growing seasons would promote the growth of many types of plants in both S1 and S2.

Only 7 genera and 9 species were found in both sites, and this result reflects the difference in vegetation between S1 and S2. Although grasses and herbs accounted for nearly 90% of the total C in both sites, S1 was grass–herb equally dominated pasture, and the S2 was herb-dominated and grass-subdominated pasture. However, from the results for the R-SDR2, the S1 was herb-dominated pasture, as the R-SDR2 of grass was 18.4% and that of herbs was 64.2%. S2 was herb-dominated and grass-subdominated pasture with respect to R-SDR2. Thus, the R-SDR2 of the grass was greater and that of the herbs was less in S2 than in S1. These results coincided with those of a previous study: the R-SDR2 of grasses increased and that of herbs decreased as the pasture was well conserved and/or managed [17].

CONCLUSIONS

The results for yields and their seasonal changes were in agreement with previous studies, and the yields were greater than those in pastures using for grazing and nearly equal to those in well conserved pastures. The R-SDR2 is an indicator of pasture condition. The proportions of grasses increase and those of herbs decrease as a pasture is well conserved and/or managed.

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