Grazing impacts on natural steppe community of eastern Mongolia

Narantuya. N

[1] Institute of Botany, the Mongolian Academy of Sciences, Ulaanbaatar210351, Mongolia.
narantuya_n@hotmail.com, narantuya@botany.mas.ac.mn

Key points.

During 2001-2003, we conducted vegetation surveys on grassland sites in steppe zone that were subjected to different livestock grazing intensities in eastern Mongolia. In this paper representing light and overgrazing were situated 5 and 15 km from the Kherlen River. The main characteristics of vegetation such as vertical structure, species composition, vegetation cover and productivity were measured and analyzed in relation to two levels of grazing pressure. We found that the total biomass decreased and the proportion of woody plants increased with increasing grazing pressure compared with Light grazing. The lightly grazed grassland exhibited high heterogeneity, the highest species diversity and richness and a high productivity due to occurrence of *Stipa*, whereas the overgrazed grassland exhibited low species diversity and a higher occurrence of *Artemisia adamsii* of poor feed quality. Based on study, we suggest immediate and full protection of the overly grazing grasslands until the vegetation was restored to a healthy state. It is necessary to implement a strategy of rotating between rests and to prevent the grasslands from further degradation.

Key words: Grassland, overgrazing, productivity, community, succession.

Introduction

Grasslands are estimated to cover 125 million hectares (ca 80%) of the total land area of Mongolia, and make up 2.6% of the global grassland vegetation (World Resources Institute, 2003). Currently about 122 million hectares of Mongolia is devoted to nomadic pastoralism, with 28% of which lying in the steppe zone. The climate on the regional arid and semiarid steppes is distinctly continental with a strong influence from the East Asia summer monsoon (Yatagai & Yasunari, 1995). Precipitation is highly variable both in time and space. Nomadic herding constitutes the major human activity in Mongolia, making grazing the dominant anthropogenic factor that affects steppe vegetation. Moreover, the arid and semiarid steppes are ecologically fragile and sensitive to seasonal and decadal changes in climate (Dennis, 1987). The intensified anthropogenic activities and climatic changes have both been concerned for contributing to degrading ecosystem productivity of the Mongolian grasslands.

Since 1940, eastern steppe ecosystem of Mongolia was investigated in relation to rational use of natural vegetation cover and grasslands. Mongolian dry steppe vegetation and grassland had been studied by Dashnyam (1969) more than 30 years and he distinguished 1103 species belonging to 89 families and 412 genera and 21 vegetation types in the steppe zone of eastern Mongolia.

Since 1970, the vegetation dynamics and flora of Eastern Mongolia were studied by Joint Mongolian-Russian Biological Complex Expedition (Main pasture types in MPR, 1974) and played large role in grassland investigation of Mongolia. Most work on community productivity has been done by Mongolian researchers from the institute of Botany, Mongolian Academy of Sciences.

A primary cause of low and declining productivity is land degradation. Mongolian grasslands are partly overstocked, particularly in semiarid region of Mongolia. Heavy grazing of livestock has in many places, and led to changes in soil and vegetation. In order to prevent further degradation and rehabilitate degraded areas, it is necessary to study the impact of grazing on this grassland.

The present work (monitoring study) was done on the territory of Bayantumen sum in East Aimag, Mongolia in 2001-2003 and were compared the dynamics of productivity, species composition and vertical structure in vegetation with different levels of grazing pressure.

Materials and methods

Study area and sites

The research area situated at N48^{0}00’89”, E114^{0}27’671” within the Kherlen river valley. The climate is temperate semiarid, with distinct continental characteristics. The annual mean temperature is 0.5^{0}C, annual precipitation 350 mm and approximately 80% of which is concentrated on the period of june-august. Chesnut and dark chestnut soils are the dominant types in the area.

We chose two grasslands in the Kherlen river valley for our monitoring study. Main criterions by which distinguished the vegetation into levels are: cover of dominated species in vegetation, mean height of plant, productivity and quality (ratio between the biomasses of palatable and unpalatable species).

a. *Artemisia adamsii* overgrazed grassland (S_1) is situated within the 5 km range from the Kherlen river at

N 48^{0}00’89” E 114^{0}27’671” were altitude is 764 m, soil is dark chestnut. Plants are exposed to overgrazing and plant mean height is very low (approximately 6 cm. table 1), vegetation cover is 10.2% and very sparse, species richness is poor. Because there sheep and cattle concentrated during the growing season or year. There dominated by woody or unpalatable by livestock or steady to grazing species such as *Artemisia adamsii, A. frigida, A. scoparia,*and also annual and biennial species of *Chenopodiaceae* families.

b. *Stipa* light grazed as control grassland (S_2) is situated at N 45^{0}54’739”, E 114^{0}28’365”within 15 km range from the Kherlen river, were plants are exposed to very light grazing , plant mean height is 35 cm, vegetation cover 62%, species richness is very high and in vegetation are dominated by Stipa grandis, S.krylovii. The altitude is 930 m, distributed to stony soils.

Measurements

We used the line transect method. From the Kherlen river to remote direction randomly was taken 15 km’s line transect in 160^0 south east (Buzzard, 1998). Along the transect within the 5 km range was choosen permanent study’s first plot (S_1), on 15 km - second plot (S_2).

On each permanent plots we were studied comparatively the vegetation structure, species composition, and vegetation cover was documented in randomly placed quadrates of 1m^2, 10 in each plot.

Sampling of above ground biomass was carried out from 1 m^2 in 10 times during the growing season. All species were cut at ground level and also was taken the litter -biomass. Samples were dried at 80 ^{0}C to content weight and weighted to the nearest 0.001g.

Canopy cover was recorded in percent for all species and measured their heights.

Data analysis

Biomass data were anylized for important species separately. The biomass components were sorted as groups of species: shrubs; grasses; legumes; sedges; warmwoods (Artemisia), forbs and litter. Above all the except litter sorted as palatable and unpalatable groups.

The all data were calculated by following formula:

1. $X= \sum_{(c)} /n;$ were n- number of replication; X- mathematical mean; c – 1.2.3…

2. $\mu (variance) = \sum (c-x)^2/ n-1;$

3. $m = \mu/n;$ were m-standard error of means. The standard error of the difference is used to access the difference between the means by the T and F tests.

4. $t_{1.2} = (X_1-X_2) / (m_1^2+m_2^2);$ were (X_1-X_2)- difference between the means

$(m_1^2+m_2^2)$-standard error of the difference.

5. $F_{1.2} = \mu_1/\mu_{2;}$

The level of significance is readily obtained from a table of T and F (Fisher and Yates, 1957).

The significance of our study is a P=0.05 or 95%.

3. Results

Overview of the two grasslands

Table 1 shows general characteristics of the two grasslands surveyed in 2001-2003. The grassland most distant from Kherlen river experienced light level of grazing, whereas the grassland closest to Kherlen river experienced the overgrazing. Plants under light grazing conditions grew taller than those overgrazing and heavy grazing conditions (plant height is a simple indicator of grazing intensity). The occurrence of *Stipa* is a characteristic grass preferred by animals in this area, decreased with increasing grazing intensity.

Table 1.

The features of the communities on the different level of grazing pressure.

The attributes of the community**.**	*Artemisia grassland* (S_1)	*Stipa grassland* (S_2)
Edificator	Artemisia adamsii	Stipa grandis
Main dominant species	Caragana microphylla	S. sivirica
	Cleistogenes squarrosa	Stipa krylovii
	Potentilla acaulis	A.bidentatum
	Sibbaldianthe adpressa	Serratula centauroides
	Salsola collina	Haplophyllum dahuricum
	Artemisia frigida	Allium anisopodium
Average number in 10 quadrats of 1m^2	19	45
Cover (%) average of 10 quadrats.	10.2	52.1
Mean height of vegetation (cm)	6	35
Total productivity: (c/ha)	2.6	20.9
a. above ground biomass	2.3	19.3
b. Litter	0.3	2.6
Distance to Kherlen river (km)	5	15
Grazing pressure	overgrazing	Light grazing

Stand (vertical) structure

Each species in the vegetation communities should layer into height strata and vegetation vertical structure had been changed negatively to increase grazing pressure.

In full flourish, the maximum height in light grazed *Stipa* community is a 50 cm, the minimum is 10 cm, then in overgrazed *Artemisia* community is a 10 and 3 cm, that vegetation vertical structure was shorten to 5 times with intensive grazing pressure.

Species composition

The total numbers of species recorded from grasslands with light grazing were higher than others, especially total number in overgrazing is lower. The species composition of *Stipa* community consists of 16 families, 28 genera, 45 species, whereas in the overgrazed *Artemisia* community was registered 15 species belonging to 13 families and 15 genera (Fig. 1).

The average number of species recorded per plot higher in *Stipa* community (S_2) than in *Artemisia* community (S_1) on overgrazing, were most likely related to the increase in cover and dominance of *Artemisia adamsii. A. scoparia*.

The families of more species are Gramineae, Compositae, Leguminosae, Rosaceae and Chenopodiaceae.

Synusia structures in the communities include seven kinds: bunch - grass; rhizome – grass; Sedge; forbs; annual-biennial herb and semi-shrub and shrub. Also classified on ecological group of water requirement, of all species 46.9% species are xerophytes or eury-xerophytes, 40.8% species are meso-xerophytes, 8.2% species are xero-mesophytes, and only 4.1% species are annual-biennial plants.

Vegetation cover

The total cover of vegetation is higher about 4 times in light grazed *Stipa* as control site than in overgrazed *Artemisia adamsii* community. A grazing induced in increase warmwood (*Artemisia*) plant species in vegetation following the reduction of herbaceous vegetation. (figure 3)

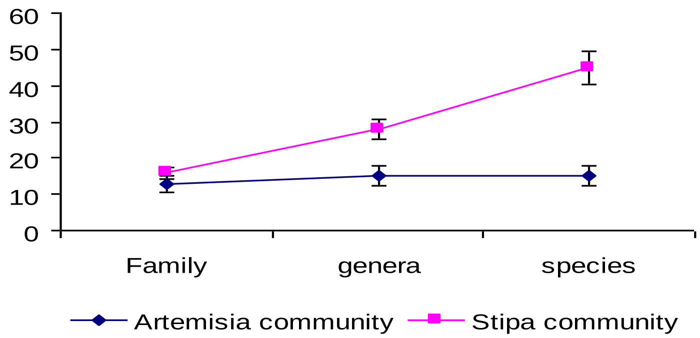

Figure 1. The species composition in two communities with differenr grazing pressure

Productivity

There was a tendency toward an increase in total productivity of vegetation with decrease grazing pressure. For example, in overgrazed community the total productivity is a 2.6 c/ha, of these: above ground biomass is a 2.3 c/ha. Litter biomass is a 0.3 c/ha, whereas total productivity in light grazed *Stipa* community is a 22.9 c/ha, that increased about 8.8 times due to increase aboveground biomass and litter (figure 4; 5). The above ground biomass sorted as groups: palatable and unpalatable and by their ratio we were assess the quality of productivity in each vegetation (figure 6).

In overgrazed *Artemisia* community the biomassa of palatable species lower than unpalatable species, because there are only dominated species of feed poor quality as *Artemisia adamsii*, *A. scoparia*, not palatable for domestic animals in growing season. There biomass of unpalatable species occupies 1.8c/ha or 78.3% of total biomass in vegetation, whereas of total biomass in light grazing community: – 92.2% palatable, 7.7%-unpalatable.

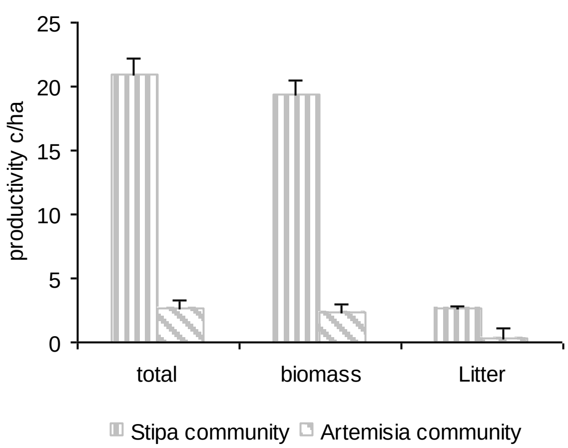

Figure 2. The productivity in two communities

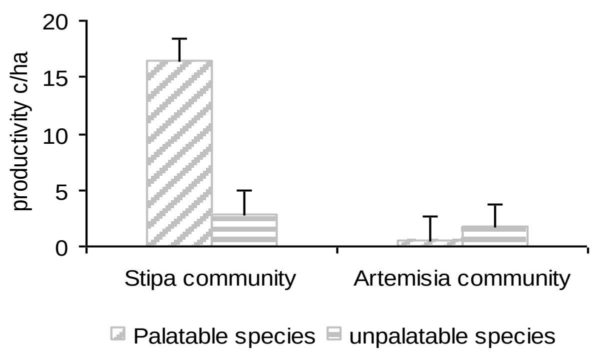

Figure 3. The proportion in productivity of palatable and unpalatable species.

Discussion

Grassland vegetation clearly changed according to the degree of degradation (intensity of use). In the overgrazed, degraded grassland, *Stipa grandis*, *S. krylovii* (Graminae) and some forbs (Leguminosae) have been seriously damaged by grazing and trampling. The number of species and species diversity on these degraded grasslands were lower, about 2.3

times, than lightly grazed grasslands (Table 1). The average height of plants with increasing grazing pressure decreased about 6 times in relation to their palatability by livestock.

The lower species richness and diversity in overgrazed grassland were most likely related to the increase in cover and dominance *Artemisia adamsii, A. scoparia* and *A. frigida* and suggest increasing grazing had a facilitating effect through reduction of the perennial palatable species. The lightly grazed grasslands have high species diversity because of the vertically stratified community structure. The similar result reported by Zhang (1985).

With decreasing grazing total productivity of vegetation was increased, especially, biomass of palatable species. In overgrazed grassland biomass of unpalatable species occupies 1.8c/ha or 78.3% of total biomass in vegetation and their quality severely deteriorated due to increasing grazing intensity. In this case, the average height, cover and biomass of *Stipa grandis* decrease sharply, whereas undesirable plants of *Artemisia* and *Potentilla* species increase.

In Mongolia does not have ungrazed natural steppe grassland, so, Mongolia has a nomadic herdering, because in our present study lightly grazed *Stipa* steppe community is as a control plot and here edificator plant is a *Stipa grandis*, *Stipa krylovii* dominants are other tall grasses: such as *Agropyron cristatum, Leymus chinensis, Cleistogenes squarrosai* and ets. Further, under overgrazing *Stipa* natural community replaced *Artemisia adamsii* dominated community. Here the grasses were eaten by livestock at the ground level, only unpalatable, woody and steady to grazing species, and especially annuals of Chenopodiaceae family were dominated. Also the community has a lot of bare ground. It is unsuitable to grassland.

From the differences among these grasslands, we judged that to prevent further degradation, necessary to provide fencing and protection for overgrazed plots, to rest of grazing or to rotate (to alternate) to grazing. The vegetation on overgrazing necessary fence to exclusive from livestock for their restoration to original vegetation conditions of high species diversity, plant biomass and plant height.

Conclusion.

1. The features of grassland community is closely related with the grazing pressure.
2. Under overgazing of livestock the *Stipa* steppe community was replaced by *Artemisia adamsii* dominated community.
3. Overgrazing leds to the reduction of productivity and it's quality.
4. In order to prevent further degradation neseccary to improve the management for use grassland under grazing of livestock.
5. To prevent further degradation necessary to rest and rotate the vegetations on the light grazing
6. The vegetation on overgrazing necessary fence to exclusive from livestock for their restoration to original vegetation conditions

References

Buzzard R. Some guidelines for assessing rangeland health. New York, 1998. p 2-21.

Chen Zuozhong, Huang Dehua and others. The model of interrelation between underground biomass of Aneurolepidium Chinensis and Stipa grandis steppe and precipitation in Inner Mongolia. In: Report from the Inner Mongolia grassland ecosystem reseach station of Academy Sinica.(1979-1988). Science Press. Beijing. China. 1990. p. 160-163.

Chen Zuozhong, Huang Dehua. A measurement to underground productivity and turnover value of Aneuroledium chinense and Stipa grandis steppe. In: Report from the Inner Mongolia grassland ecosystem reseach station of Academy Sinica.(1979-1988). Science Press. Beijing.China.1990.p. 42-42-45.

Dashnyam B., The vegetation and flora of Eastern Mongolia. 1974. p. 11-32.

Dennis P., Sheehy. Using deferred rotation grazing to improve the native rangelands of East-central Inner Mongolia. In: In: Psoceedings ot the international symposium on grassland vegetation. August 15-20, 1987. Hohhot.(edit. Yang Hanxi).Science Press, Beijing, China. p. 613-620.

Li Yong-hong. Impact of grazing on Aneurolepidium chinensis stepee and Stipa grandis steppe in Inner Mongolia.. Acta ecologica/Acologia Applicata, 1989.v-10. #1. p. 31-46.

Narantuya N., Jargalsaihan L. The present state of Gleistogenes squarrosa community in Eastern Mongolia. In: Proceedings of the reseach conference on Contribution of biological studies to the improvement of Rangeland Management in steppies of Mongolia. Ulaanbaatar. March 18. 2002. p. 18-23.

Parton WJ, Scurlock JMO, Ojima DS et al. (1995) Impact of climate change on grassland production and soil carbon worldwide. Global Change Biology, 1, p. 13–22.

Plokhinsky N.A. Biological statistic in field work. Novosibirsc,1982. p. 151-167.

Poissonet J., Li Yonghong and others. An ecological study on the typical steppe of Inner Mongolia with the methods of the "Ecotheque" of Montpellier. In: Report from the Inner Mongolia grassland ecosystem reseach station of Academy Sinica.(1979-1988). Science Press. Beijing. China. 1990. p. 268-272.

Wang Yifeng. Strusture and seasonal dynamics of aboveground biomass of Stipa grandis community. In: Report from the Inner Mongolia grassland ecosystem reseach station of Academy Sinica.(1979-1988). Science Press. Beijing. China. 1990. p. 28-31.

Wei Zhang. Biomass development under protection from grazing in steppe vegetation in Inner Mongolia. China In: Vegetation dynamics in relation to livestock grazing in a semiarid steppe in Inner Mongolia. Uppsala university.,(edit. by Wei Zhang).1995.p. 2-8.

Wei Zhang. Changes in species diversity and canopy cover in steppe vegetation in Inner Mongolia under protection from grazing. In: Vegetation dynamics in relation to livestock grazing in a semiar id steppe in Inner Mongolia. Uppsala university. .,(edit. by Wei Zhang). 1995. p. 2-10.

Yasunari T (2003) The role of large-scale vegetation and land use in the water cycle and climate in monsoon Asia. In: Challenges of a Changing Earth – Proceedings of the Global Change Open Science Conference, Amsterdam, the Netherlands, 10–13 July 2001. Series: Global Change – The IGBP Series (eds Steffen W, Jaeger J,Carson DJ, Bradshaw C), pp. 129–132. Springer-Verlag, New-York.

Yoshimitsu Saito, Yoshito Yamamoto and others. Changes in the semi-natural grassland vegetation of central japan. In: Psoceedings ot the international symposium on grassland vegetation. August 15-20, 1987. Hohhot.(edit. Yang Hanxi).Science Press, Beijing, China. P.257-264.

Yatagai A, Yasunari T (1995) Interannual variations of summer precipitation in the arid/semi-arid regions in China and Mongolia: their regionality and relation to the Asian Summer Monsoon.Journal of the Meteorological Society of Japan, 73, p. 909–923.

Zhong Yankai, Piao Shunji. Experimental results by mowing succession in Aneurolepidium chinense steppe. In: Report from the Inner Mongolia grassland ecosystem reseach station of Academy Sinica.(1979-1988). Science Press. Beijing. China. 1990. p.46-48.