CLIMATIC AND ALTITUDINAL EFFECTS ON PLANT SPECIES RICHNESS AND COVERAGE IN MONGOLIAN FORB-STEPPE

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Abstract. *Main compound of Mongolian ecosystem is natural grassland. Because of increasing effects from humans and animals to the natural grassland, its vegetation cover has been changing considerably. The goal of this paper was to assess climatic and altitudinal effevts on planr species richness and coverage in Mongolian forb-steppe. Vegetation data were collected, using phytosociological methods, from 40 stands in eight areas a crossing approximately 300 km and covering a large proportion of the southeast part of Darkhan-Uul province's area. Mean species number was 18 and 15 in highland and lowland, indicating species number was higher in highland than in lowland (Mann-Whitney U-test, p=0.02). The mean species number was 18 and 16 near to (< 850 m) and far from river (> 2000 m) and it showed insignificance (Mann-Whitney U-test, p=0.23). All sites within highlands showed indifference of species number among years. In lowland, sites which near to river (< 850 m) showed lower species number for year with drought in June (2010), compared to for years with drought in May and normal weather. Species number in highlands was insignificant by years. That in lowlands was lower for year with drought in June than years with drought in May and normal weather. This difference was found in Zeder and Temeen Olom.*

Keywords: *plant communities, vegetation cover, dominant species, species richness.*

INTRODUCTION

Grassland plant biodiversity is higher during rainy periods than sustained drought periods (DE BELLO ET AL., 2006; LOESER ET AL., 2006; ZHAO ET AL., 2011). SHIMONO ET AL (2010) provided evidence that altitude plays a large role in regulating species composition. Plant biodiversity were investigated in various steppe types in Mongolia (FERNANDEZ-GIMENEZ AND ALLEN-DIAZ, 1999; FUJITA ET AL., 2009; LIU ET AL., 2013). Previous studies found a positive relationship of plant diversity with precipitation in Mongolian steppe, suggesting considerable drought controls on species composition (FUJITA ET AL., 2009). Also, the role of livestock grazing and precipitation in determining biodiversity in semi-arid mountain and arid desert steppes, respectively, was recognized (FERNANDEZ-GIMENEZ AND ALLEN-DIAZ, 1999).

Previous studies have found a decreasing trend in species richness with altitude (KITAYAMA 1992; NAVARRO 1992; STEVENS 1992; PATTERSON ET AL. 1998; VAZQUEZ AND GIVNISH 1998; ODLAND AND BIRKS 1999). GRYTNES AND VETAAS (2002) reported that number of species in 100-m altitudinal bands increases steeply with altitude until 1,500 m. Between 1,500 and 2,500 m, little change in the number of species is observed, but above this altitude, a decrease in species richness is evident. Tree species diversity is higher in the lowlands and middle mountain zones than in the lower mountain and the lower diversity in the lower mountain zone could reflect less precipitation and frequent fires (ZHU ET AL., 2015). Researchers explained that altitudinal differences of plant biodiversity can be related with climate (SHARMA ET AL., 2009; ZHU ET AL., 2015) and grazing intensity (NING ET AL., 2002) and fire frequency (ZHU ET AL., 2015). The change of biodiversity is so complicated that it cannot be explained with the simple corresponding causality (NING ET AL., 2002).

LIU ET AL (2013) suggested that grazing and drought are equally important in determining biodiversity in the typical-steppe zone, which occurs between mountain and desert

steppes. NARANTSETSEG ET AL (2014) classified steppe zone into three sub-zones, such as forb-, typical- and semi-desert-steppe. Darkhan province locates in the forb-steppe sub-zone. Darkhan city has with a large population, numerous industries and agricultures, suggesting in recent years, due to direct and indirect effects of human in addition to climate change. Vegetation cover in this city has changed and degradation rate increased. (CHOGNII 2001; BATKHISHIG 2012). Due to intensive migration of herder families after social-age from countryside to the surrounding area of Darkhan province, vegetation community changes are increased. The purpose of this study was to describe whether both climatic, grazing and altitudinal effects are contributed to plant species richness and cover in the forb-steppe sub-zone, Mongolia.

MATERIAL AND METHOD

Darkhan province is located in northern Mongolia which is in the eastern valley of Kharaa river. The province's territory is 700–1500 meters above sea level and lies between the latitudes 49°07'N and 49°54'N, and longitudes 105°50'E and 106°49'E. The total area of the province is about 3275 km^2. It consists of small mountains, low hills and hillocks, rivers, valleys and holms. The Darkhan province belongs to the Central Khangai zone. Long-term average of air temperature was 0.6ºC and average annual precipitation amount was 361.0 mm. Aridity index, according to de Martone (1927) was 34.12, indicating forb-steppe dominates in Darkhan province. It falls as rain in the summer season and monthly rainfall reaches a maximum in August (HILBIG 1995; Van Staalduinen & Werger 2007). Climate diagram, for the study years 2009–2012 can be seen in Fig. 1. The diagrams are according to WALTER AND LIETH (1960), where temperature and precipitation is given on a 1:2 scale to determine drought period duration (i.e. 20 mm precipitation corresponds to 10 °C air temperature). Drought was occurred in May at 2009 and in June at 2010 but it was not occurred at 2011 and 2012.

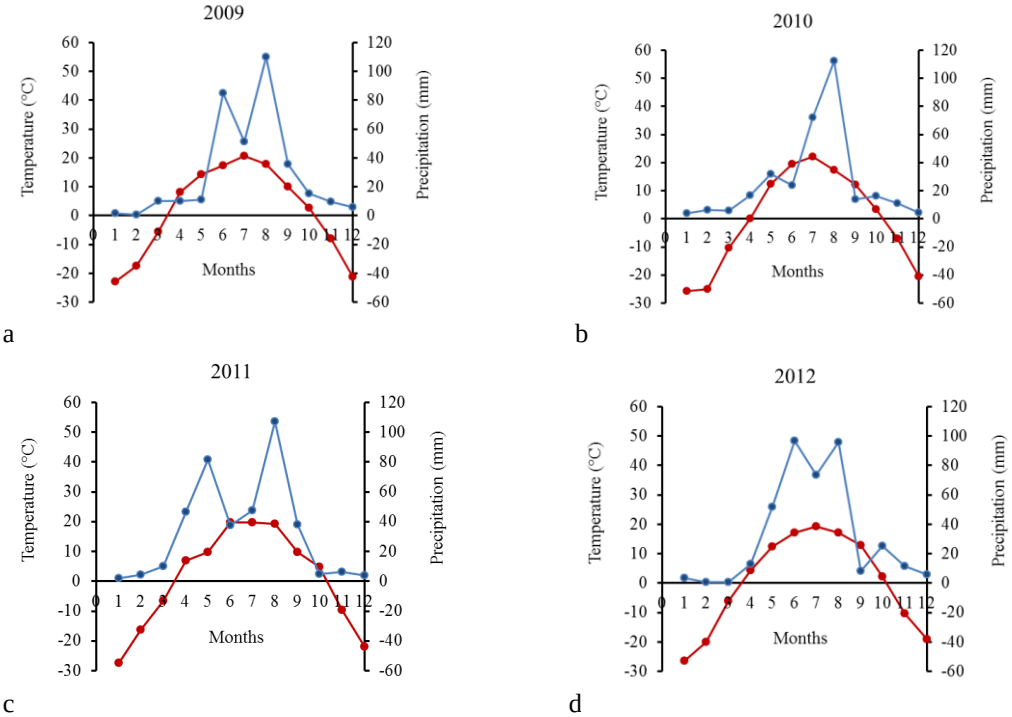

Fig.1.Climate diagrams for Darkhan city province in Mongolia. Numerical values are taken from the Darkhan climate station for the period 2009 – 2012. *Red line*–Air temperature, *Blue line*–Precipitation.

Vegetation data was sampled during the period August 1–7 in 2009 – 2012 for the study area in Darkhan province, Mongolia. Seven sites and five plots of 1 m^2 within site for vegetation descriptions were selected (Table 3). The vegetation descriptions were repeated each study year. Distance between site and river was used to evaluate grazing effect and near the river grazing effect is stronger than far from river (SASAKI ET AL, 2005). Mining effect became to increase for 2010, 2011 and 2012 in Bichigt khad. Altitude in our study area was classified in two groups, such as lowland which is <900 m of altitude and highland which is >1000 m of altitude.

Table 1.

Names and general condition of the study sites in Darkhan-Uul province, Mongolia.

Sites name	Distance between site and river (m)	Location	Altitude (m)	Dominant species
Lowlands				
Zeder	850	49°33'487N; 106°31'300E	855	*Stipa baicalensis – Galium verum – Artemisia frigida*
Deltiin Khundii	2000	49°32'108N; 106°13'313E	705	*Stipa Krylovii – Caragana michrophylla*
Temeen Olom	30	49°33'542N; 106°15'228E	720	*Grass – Potentilla anserine – Halerpestis salsuginosa*
Highlands				
Ugluu Uul	5000	49°12'269N; 106°11'144E	1225	*Stipa sibirica – Bupleurum scorzonerifolium – Galium verum*
Bichigt Khad	600	49°27'691N; 106°41'091E	1029	*Grass – Geranium pratense – Fragaria orientalis*
Khawtgain Dawaa	3000	49°14'477N; 106°39'797E	1203	*Stipa sibirica – Achillea asiatica – Phlomis tuberosa*
Ikh Darkhan	5000	49°16'099N; 106°24'971E	1239	*Festuca lenensis-Potentilla sericea-Arenaria capillaris*

The vegetation data consisted of species number and total cover. At least two herbarium specimens were prepared for all species, including unidentified species and those belonging to difficult groups (e.g. *Fabaceae*). Total cover was measured by the method of RAMENSKY (1971) and nomenclature follows GRUBOV (2001). The location of sampling sites was recorded with a Global Positioning System (GPS) receiver (Table 3). Mann-Whitney U-test was used to compare species richness and total cover between highland and lowland and between sites near to and far from river and Tukey HSD test to compare those among years.

RESULTS

Mean species number was 18 and 15 in highland and lowland, indicating species number was higher in highland than in lowland (Mann-Whitney U-test, p=0.02). The mean species number was 18 and 16 near to (< 850 m) and far from river (> 2000 m) and it showed insignificance (Mann-Whitney U-test, p=0.23). All sites within highlands showed indifference of species number among years. In lowland, sites which near to river (< 850 m) showed lower species number for year with drought in June (2010), compared to for years with drought in May and normal weather. Site which far from river showed indifference of species number among years (Table 2). Species number in highlands was insignificant by years. That in lowlands was lower for year with drought in June than years with drought in May and normal weather. This difference was found in Zeder and Temeen Olom.

Table 2.

Differences of species number between highlands and lowlands in Darkhan province, Mongolia

	Elevation	2009	2010	2011	2012
Ikh Darkhan	High	15.0 [a]	15.6[a]	16.8[a]	16.2[a]
Ugluu Uul	High	18.2[a]	17.6[a]	20.4[a]	19.6[a]
Bichigt Khad	High	19.0[a]	17.4[a]	19.6[a]	19.6[a]
Khawtgain Dawaa	High	18.8[a]	18.6[a]	20.0[a]	19.4[a]
Zeder	Low	19.0[a]	16.8 [b]	19.8[a]	19.0[a]
Deltiin Khundii	Low	9.8[a]	7.6[a]	9.6[a]	9.4[a]
Temeen Olom	Low	18.4[a]	14.2 [b]	17.4[a]	17.4[a]

[a]– represent significance of Tukey HSD test (P<0.05) and comparison among rows.

Mean of total cover was 56% and 53% in highland and lowland and statistical analysis showed insignificance (Mann-Whitney U-test, p=0.4). The mean of total cover was 59 and 51 near to and far from river and it showed insignificance (Mann-Whitney U-test, p=0.09). The differences in total cover were insignificant during years with drought in May and normal weather, whereas the differences were significant during year with drought in June (Table 3). Three sites within highlands showed indifference of total coverage among years but in Bichigt khad, total coverage was higher for year with drought in May, compared to years with drought in June and normal weather. In lowland, all sites showed lower cover during year with drought in June, compared to years with drought in May and normal weather.

Table 3.

Differences of total cover between highlands and lowlands in Darkhan province, Mongolia

	Elevation	2009	2010	2011	2012
Ikh Darkhan	High	36[a]	36[a]	36[a]	38[a]
Ugluu Uul	High	52[a]	53[a]	55[a]	55[a]
Bichigt Khad	High	63[a]	58 [b]	58 [b]	58 [b]
Khawtgain Dawaa	High	73[a]	72 [a]	75[a]	75[a]
Zeder	Low	43[a]	38 [b]	43[a]	42[a]
Deltiin Khundii	Low	43[a]	37 [b]	43[a]	43[a]
Temeen Olom	Low	78[a]	74 [b]	79[a]	78[a]

[a]– represent significance of Tukey HSD test (P<0.05) and comparison among rows.

DISCUSSION

Species richness is higher in the forb-steppe than in typical and semi-desert-steppe (Narantsetseg et al., 2015). Present study reveals altitudinal differences of species richness and total cover within the forb-steppe. Species richness in highlands was indifferent among years and by site-river distance but it in lowlands was different by site-river distance. Total cover in highlands was also indifferent among year and by site-river distance, excluding Bichigt khad which disturbed by mining effect whereas it in lowlands was different among year. This suggests that grazing and drought might affect on species richness and total cover in lowlands, compared in highlands. Fernandez-Gimenez and Allen-Diaz (1999) suggested that both

variation in precipitation and grazing factors play important roles in determining vegetation composition and biomass in the steppe.

Sasaki et al (2005) recognized high and low grazing pressure near to and far from spring and edible plant species disappear with high grazing pressure. Present results showed lower species richness near to river (< 850 m), suggesting high grazing pressure near to river. Climate diagrams showed that drought was occurred in May and June of 2009 and 2010 while normal weather during last two years. Total cover in highlands was not linked to drought seasonality but that in lowlands was lower in year with drought in June. This indicates that June drought might be effective on total cover in lowlands of the forb-steppe, stronger than May drought. Present results suggest that within forb-steppe, different factors might play on species richness and total cover, resulting in altitudinal gradient.

CONCLUSION

- All sites within highlands showed indifference of species number among years. In lowland, sites which near to river (< 850 m) showed lower species number for year with drought in June (2010), compared to for years with drought in May and normal weather.
- Site which far from river showed indifference of species number among years. Species number in highlands was insignificant by years. That in lowlands was lower for year with drought in June than years with drought in May and normal weather. This difference was found in Zeder and Temeen Olom.
- Mean of total cover was 56% and 53% in highland and lowland and statistical analysis showed insignificance (Mann-Whitney U-test, p=0.4). The mean of total cover was 59 and 51 near to and far from river and it showed insignificance (Mann-Whitney U-test, p=0.09). The differences in total cover were insignificant during years with drought in May and normal weather, whereas the differences were significant during year with drought in June.
- Three sites within highlands showed indifference of total coverage among years but in Bichigt khad, total coverage was higher for year with drought in May, compared to years with drought in June and normal weather. In lowland, all sites showed lower cover during year with drought in June, compared to years with drought in May and normal weather.

BIBLIOGRAPHY

BATIMA, P., L. NATSAGDORJ, P. GOMBLUUDEV, AND B. ERDENETSETSEG. 2005. Observed climate change in Mongolia. New York: AIACC Working Paper.

BATKHISHIG, B. 2012. Community-based rangeland management and social-ecological resilience of rural Mongolian communties. Colorado State University, Fort Collins.

CHOGNII, O. 2001. The feature of regeneration grassland with using nomadic grazing in Mongolia. Mongol sudlal, Ulaanbaatar.

DARIIMAA, S., B. ALTANTSETSEG, AND B. TSERENNADMID. 2009. Classification, distribution and ecology of vascular plant flora in Darkhan city aimag, Mongolia. MSUE. Treatise of Natural Sciences **2:**98-109.

GRUBOV, V. I. 1982. Key to the Vascular Plants of Mongolia. NAUKA, Leningrad.

GRUBOV, V. I. 2001. Key to the Vascular plants of Mongolia. NAUKA, Leningrad.

HILBIG, W. 1995. The vegetation of Mongolia. SPB Academic Publishing, Amsterdam.

JONGMAN, R. H., C. J. TER BRAAK, AND O. F. VAN TONGEREN. 1995. Data analysis in community and landscape ecology. Cambridge University Press.
LEPŠ, J., AND P. ŠMILAUER. 2003. Multivariate analysis of ecological data using CANOCO. Cambridge University press.
OCHIR, J. 1985. The vegetation and pasture of Western Khentei Mountain. Case study of flora and vegetation of Mongolian People´s Republic. Biological Academy of Mongolia, **5:**111-118.
TSEGMID, S. 1969. Physical geography of Mongolia, Ulaanbaatar. Mongolian Academy of Sciences., Mongolia.
TSERENBALJID, G. 1987. Feature of Phytosociology Biological Academy of Mongolia. Mongolian Biological Academy. **10:**7-14.
TSERENNADMID, B., AND B. ODONCHIMEG. 2012. Results of vegetation study of a mountain steppe in Khongor district, Darkhan city province, Mongolia. Pages 104-107. Proceedings of the International scientific-practical conference dedicated to the 60th anniversary of the Faculty of Agronomy. Ulan-Ude.
ULZIIKHUTAG, N. 1989. Overview of the flora of Mongolia. State Publishing, Ulaanbaatar.
VAN STAALDUINEN, M. A., AND M. J. A. WERGER. 2007. The steppes of Mongolia. The impact of herbivores in a Mongolian forest steppe. Applied Vegetation Science **10:**299-306.
WALTER, H., AND H. LIETH. 1960. KLIMADIAGRAMM-WELTATLAS. G. FISCHER.
YUNATOV, A. A. 1950. Fundamental Characteristics of the Vegetation of the Mongolian People's Republic. AS USSR Publishers, Leningrad.