Distance-to-Well Effects on Plant Community Based on Palatability and Grazing Tolerance in the Desert-steppe of Mongolia

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ABSTRACT

Wells in grasslands are usually accompanied with increased traffic by humans and livestock. The purpose of this study was to detect whether plant community structure differs in spatial arrangement with different grazing gradients in the desert steppe of Mongolia. We found poor correlation between total coverage and distance-to-well in big-shrub and shrub-limited sites but strong correlation in the small-shrub site. Dominance of palatable plants along the transect appeared in the big-shrub site but that of palatable, grazing avoider and grazing tolerant plants appeared in other two sites. The results show that these communities might respond differently to grazing pressure. Livestock trampling was limited to near the well and then grazing might be effective far from the well, because all sites showed dominance of palatable herbaceous plants. Sub-dominance of Eurotia ceratoides appeared nearest to the well and followed Caragana spp. sub-dominance. Ajania spp. sub-dominance appeared more away than E. ceratoides and Caragana spp. Dominance of palatable herbaceous plants appeared near the well, compared with that of shrubs. In all sites, palatable herbaceous plant community was replaced by grazing tolerant plant community near the well and shrubs disappeared. This indicates that succession after grazing might be faster in herbaceous plant community than shrub one.

Keywords: grazing, trampling, palatable plant, grazing tolerant plant

INTRODUCTION

The Mongolian Plateau is one of Asia's largest biomes. With its highly diverse floral communities, environmental gradient across an extensive region, and long human impact, this area provides a unique opportunity to explore the interactions of the environment, plants, and humans in creating the diverse spatial pattern of this ecosystem (Hilbig 1995; Karamysheva and Khramtsov 1995). Generally, the south is characterized as drier and hotter than the north of Mongolia (Pyankov et al. 2000).Hence, plant species richness, diversity, and community structure can be different among natural zones (Fujita and Amartuvshin, 2013).

In the desert steppe, the effect of livestock grazing on plant community structure is generally weaker than interannual rainfall variability (Fernandez-Gimenez and Allen-Diaz,

1999; Stumpp et al., 2005).However, during dry seasons, drought-resistant shrub species such as *Caragana* spp. which can absorb water deep in the soil, are a good forage resource for livestock (Fujita et al., 2013), and succulent small-shrubs can also be grazed by livestock (Jigjidsuren and Johnson, 2003). In spite of primary role of climate in determination of desert-steppe plant community, livestock grazing might create a more heterogeneous spatial pattern of plant communities.

The purpose of this study was to detect whether plant community structure differs in spatial arrangement with different grazing gradients in the desert steppe region of Mongolia.

MATERIALS AND METHODS

We selected 3 sites which locate in same size of valleys in the desert steppe region of Mongolia. Each can be characterized with shrub types: big-shrub site (45°36'18.34"N, 100°46'29.21"E), small-shrub site (45°12'23.24"N, 101°06'33.67"E), and shrub-limited site (45°27'27.62"N, 101°07'11.96"E), respectively. We designated the big- and small-shrub sites where *Caragana* spp. and *Ajania* spp. co-exist with the second dominant of herb and grass, respectively, while the shrubs are not dominant in the shrub-limited site. Mongolia's climate is continental, with cold-dry winter and warm-wet summers (Fernandez-Gimenez and Allen-Diaz, 1999) but our study area was drier than the forest-steppe and steppe zones. Mean annual air temperature and precipitation are 4.8°C and 95 mm in the desert-steppe. Soil in our study area was desert-grey type (Sodnom & Yanshin, 1990) with dominant *Stipa gobica*, *S. glareosa* of grass, *Allium polyrrhizum*, *A. mongolicum* of forb (Fernandez-Gimenez, 1997) and *Caragana* spp of shrub (Fujita and Amartuvshin, 2012).

We performed a vegetation survey in July, 2014. Transect direction was selected along valley. A single transect was recorded for each well site. Species dominance was recorded at every 100 m interval away from the well, up to 1620 m. Three plots of 1 x 1 m at each 100-m interval were used in each well site. For each plot, the primary and secondary dominant species were identified and their respective coverage fractions were visually estimated and recorded. Each 1 x 1 m plot was considered a sub-sample and they are averaged to obtain the value for that location (Figure 1). We did not replicate transects within well-site, because of time limitation. So, all results in this study cannot be inferred to apply more widely than our specific sites.

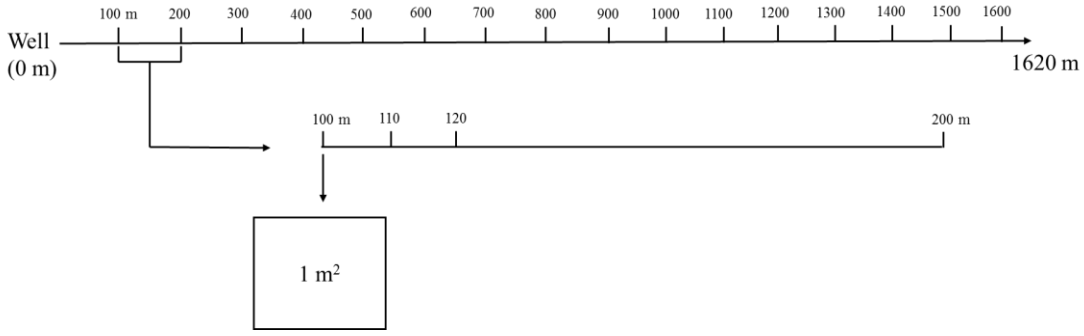

Figure 1. Well-transect design within site for field survey

Pasture plants are divided into two groups which are palatable and grazing tolerant (Jigjidsuren and Johnson, 2003). Fujita et al. (2002) reported plants which avoid grazing in Mongolian pasturelands, based on creeping and rosette growth forms. Dominant plant species observed through well-transects were divided into three groups: palatable, grazing avoider, and grazing tolerant.

We used Spearman Rank Correlation (Rs) to calculate correlation between coverage and distance from well and Tukey HSD test to compare coverage between different distances within transects showed poor correlation between total coverage and distance.

RESULTS

Total coverage in small-shrub site positively correlated with transect distance (Rs = 0.89, $p < 0.0001$) but significant patterns were not found at big-shrub (Rs = 0.3, $p > 0.05$) and shrub-limited sites (Rs= -0.2, $p > 0.05$). Big-shrub site showed densest coverage along the transect. Total coverage was denser in shrub-limited site than in small-shrub site within 400-420 m while it was denser in small-shrub site far from well (Figure 2). In the big-shrub and shrub-limited sites, coverage increased up to 300-320 m away from wells (Tukey HSD, $p < 0.05$) but decreased to 400-420 m ($p < 0.05$). Plots with grass and herb showed sparse coverage although plots with big shrubs showed dense coverage. Also, plots without shrubs at 200-220 m in big-shrub site showed dense cover.

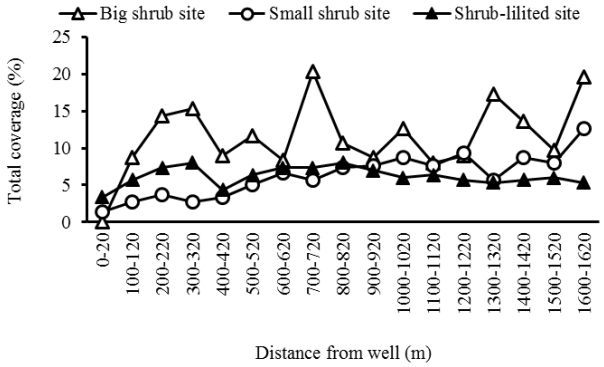

Figure 2. Changes of total coverage throughout transect from well in big and small-shrubs and shrub-limited sites.

Primary dominance of palatable grasses appeared along the transect in the big-shrub site, excluding one plot with grazing avoider species (600-620 m) but those were different in other sites. The primary dominance of grazing avoider species appeared near the well and palatable grass away from the well in the small-shrub site while tall grazing-tolerant species dominated near the well and palatable grass away from well in the shrub-limited site (Table 1). Sub-dominance of *Eurotia ceratoides* appeared nearest to the well and followed *Caragana* spp. sub-dominance. *Ajania* spp. sub-dominance appeared more away than *E. ceratoides* and *Caragana*spp (Table 2).

DISCUSSION

We found poor correlation between total coverage and distance-to-well in big-shrub and shrub-limited sites, over the full transect (1620 m), except within 200-220 m of the well, but strong correlation in the small-shrub site. Dominance of palatable plants along the transect appeared in the big-shrub site but that of palatable, grazing avoider and grazing tolerant plants appeared in other two sites. Previous studies reported that total coverage is poorly or moderately correlated with distance from water sources in the desert-steppe (Stumpp et al., 2005; Sasaki et al., 2005). Fujita et al. (2002) reported that livestock selectively graze palatable plants while grazing tolerant plants can resist grazing, chemically and morphologically. Also, they suggested that livestock mostly cannot graze low height plants, because of creeping or short culms. Our and other results suggest that these communities might respond differently to grazing pressure.

Both livestock trampling and grazing can affect plant communities (Fernandez-Gimenez et al., 2012). Our result showed that within 400-420 m of transect away from the well, creeping plants (*C. ammanii*) dominated in the small-shrub site. Trampling decreases the vertical height and increases basal diameter of plants (Xu et al., 2013). Also, increasing coverage of grazing tolerant plants up to 200-220 m indicate that trampling effect might be strongest in 0-20 m and then decrease up to 200-220 m, because livestock trampling damaged branches of grazing tolerant plants. The results indicate that livestock trampling was limited near the well and then grazing might be effective far from well, because all sites showed dominance of palatable herbaceous plants. Fujita et al (2012) reported that coverage of *A.mongolicum* is dense in shrub sites but *A. polyrrhizum* in non-shrub sites, because livestock selectively graze *A. mongolicum* better than *A. polyrrhizum* (Jigjidsuren & Johnson, 2003). We found co-existence of both *Allium* species near the well in big-shrub site but did not find their co-existence within dominants in other two sites.

Table 1. Primary dominance of herbaceous plant species along the transect in our study sites

distance [m]	Primary dominant		
	Big-shrub site	Small-shrub site	Shrub-limited site
0-20	-	*Convolvulus ammanii*	*Peganum nigellastrum*
100-120	*Allium mongolicum* *Allium polyrrhizum*	*Stipa gobica*	*Peganum nigellastrum*
200-220	*Allium polyrrhizum*	*Convolvulus ammanii*	*Peganum nigellastrum*
300-320	*Allium polyrrhizum*	*Stipa gobica*	*Stipa glareosa*
400-420	*Cleistogenes soongorica*	*Stipa gobica*	*Iris bungei*
500-520	*Stipa glareosa*	*Stipa gobica*	*Stipa glareosa*
600-620	*Convolvulus ammanii*	*Stipa gobica*	*Stipa glareosa*
700-720	*Agropyron cristatum*	*Stipa gobica*	*Stipa glareosa*
800-820	*Agropyron cristatum,* *Cleistogenes squarrosa*	*Stipa gobica*	*Stipa glareosa*
900-920	*Stipa glareosa*	*Stipa gobica*	*Stipa glareosa*
1000-1020	*Cleistogenes soongorica*	*Stipa gobica*	*Stipa glareosa*
1100-1120	*Stipa glareosa*	*Stipa gobica*	*Stipa glareosa*
1200-1220	*Stipa glareosa*	*Stipa gobica*	*Stipa glareosa*
1300-1320	*Stipa glareosa*	*Stipa gobica*	*Stipa glareosa*
1400-1420	*Stipa glareosa*	*Stipa gobica*	*Stipa glareosa*
1500-1520	*Stipa glareosa*	*Stipa gobica*	*Stipa glareosa*
1600-1620	*Stipa glareosa*	*Stipa gobica*	*Stipa glareosa*

Table 2. Sub-dominance of shrub species along the transect in our study sites

distance [m]	Secondary dominant		
	Big-shrub site	Small-shrub site	Shrub-limited site
300-320	*Eurotia ceratoides*	-	-
700-720	*Caragana bungei*	-	-
900-920	*Eurotia ceratoides*	-	-
1200-1220	-	*Ajania trifida*	-
1300-1320	*Caragana bungei*	-	-
1400-1420	-	*Ajania trifida*	-
1500-1520	-	*Ajania trifida*	-

E. ceratoides showed denser coverage near the water source (Stumpp et al., 2005) while *Artemisia schisinskii* (a palatable shrub) showed denser coverage with increasing distance from water source (Fernandez-Gimenez and Allen-Diaz, 1999). Similarly, dominance of *E. ceratoides* appeared near well while dominance of *Caragana* spp (a palatable shrub) far from well. It suggests that palatability of *E. ceratoides* might be lower than of *Caragana* spp. Also, dominance of small-shrub (*Ajania* spp.) appeared farthest, suggesting more sensitive to grazing than above mentioned shrubs. Dominance of palatable herbaceous plants appeared near the well, compared with that of shrubs.

Good palatable herbaceous plants grow well in the shrubs (Fujita and Amartuvshin, 2012). Fujita et al. (2012) suggested that *Caragana* spp keeps green biomass and is grazed by livestock during drought season but herbaceous plants keep underground storage and are grazed during wetter season. Our results indicate that livestock might weakly graze both herbaceous and shrub species along the transect in the big-shrub site but they might strongly graze those in shrub-limited site. Also, livestock might moderately graze those in the small-shrub site. In all sites, a palatable herbaceous plant community was replaced by a grazing tolerant plant community near the well but shrubs plant community disappeared. This indicates that succession after grazing might be faster in herbaceous plant community than shrub one.

The present study used few well-sites, limiting generalizability. Also, we did not count livestock in our study sites, due to time limitations, hence, this paper cannot evaluate grazing pressure in our study sites, even in desert-steppe zone. However our results can be used to improve pasture management in dry regions of Mongolia. It is necessary to make further comprehensive research on how vegetation communities respond to grazing pressure in desert-steppe zone.

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