Chapter 12
Use of Steppe Vegetation by Nomadic Pastoralists in Mongolia

Urianhai Galzuud Nachinshonhor

Keywords Mongolia • Steppe ecosystem • Aboveground productivity • Nomadic pastoralism • Sustainability

12.1 Introduction

About a quarter of global terrestrial ecosystems are occupied by herbaceous vegetation (Shantz 1954), such as steppe, prairie, savanna, and pampas. Almost all these herbaceous ecosystems are subject to a strong human influence. In the severe continental climates on the Mongolian plateau, steppe ecosystems cover more than 70% of the land (Yunatov 1976; Zhang 1990), and nomadic pastoralism developed here in ancient times (Bazargur et al. 1989; Tumurjav and Erdenetsogt 1999; Sodnoi 2009).

Several studies have described the nomadic pastoralism regime in the Mongolian plateau in terms of geographic, meteorological, economic, and anthropological aspects (Simukov 1935; Batnasan 1972; Myagmarjav 1974; Bazargur et al. 1989; Humphrey and Sneath 1999). These studies proposed that the productivity of steppe vegetation is the main driving factor of nomadic pastoralism, but concrete evidence is still lacking. There are also several studies on Mongolian steppe ecosystem in terms of vegetation ecology (Yunatov 1968; Ulzykhutag 1985; Hilbig 1995), but how the ecosystem is influenced by nomadic pastoralism is still unclear.

Recently, aspects of the relationship between the robustness of the steppe ecosystem and nomadic pastoralism in Mongolia have been reported (Fernandez-Gimenez and Allen-Diaz 1999; Fernandez-Gimenez 2000; Kakinuma et al. 2008;

U.G. Nachinshonhor (✉)
Okayama University Graduate School of Environmental Science, Okayama, Japan
e-mail: nachin@cc.oakayama-u.ac.jp

N. Yamamura et al. (eds.), *The Mongolian Ecosystem Network: Environmental Issues Under Climate and Social Changes*, Ecological Research Monographs,
DOI 10.1007/978-4-431-54052-6_12,

Sasaki et al. 2009; Wesche et al. 2010), but these studies were conducted over short experimental periods and thus lacked sensitivity. The present study attempted to clarify the relationship between the sustainability of steppe ecosystem and nomadic pastoralism using 12 years of vegetation data obtained in a livestock exclosure and in control sites and 7 years of nomadic migration information from Bayan-Unjuul County, Tuv Prefecture, Mongolia.

12.2 Material and Methods

12.2.1 Study Site

The study site (46°49′47.46″ N, 105°47′35.34″ E; elevation, 1,354 m) is located 30 km southwest of Bayan-Unjuul County, the center of Tuv Prefecture in Mongolia. Between 1998 and 2009, mean annual temperature was 0.6°C and mean annual precipitation was 154.3 mm (Institute of Metrology and Hydrology of Mongolia). The precipitation coefficient of variation (CV) was 30.7% in this period, corresponding to a nonequilibrium system according to Ellis and Galvin (1994), where the precipitation CV of the system is near to or exceeds 30%.

The vegetation is dominated by monocotyledons (*Agropyron cristatum* and *Stipa krylovii*), perennial dicotyledons (*Artemisia adamsii*), annual dicotyledons (*Chenopodium* spp.), and shrubs (*Caragana* spp.). As in almost all Mongolian steppe areas, the natural vegetation in Bayan-Unjuul is used as rangeland to pasture camels, horses, cattle, sheep, and goats in a traditional nomadic pastoral system, where livestock are moved in both time and space (Nachinshonhor et al. 2003).

12.2.2 Experimental Method and Data Collection

In June 1999, we built a 1-ha (100 × 100 m) exclosure of wooden poles and iron wire to prevent livestock grazing (Exclosure site), and the area outside the exclosure was used as the Control site. Large wild ungulates are found in the Control site, but their effects on natural vegetation are assumed to be very small in comparison with the effects of livestock. Aboveground plant biomass is maximal in late August, and we adopted the aboveground biomass in the Exclosure site in late August as an index of annual plant production. The difference in aboveground biomass between Exclosure and Control sites was considered as the grazing effect of livestock.

In late August of every year from 1999 to 2010, we sampled plant aboveground parts from 1 × 1 m areas, with four replicates, in both the Exclosure and Control sites. Species were identified, and dry mass assessed. We identified aboveground parts of shrubs as new branches and leaves, and old branches were grouped separately. The taxonomic nomenclature follows Yunatov (1968).

Table 12.1 Effects of year and grazing on aboveground biomass and species diversity (Shannon–Wiener index) of community and functional groups

Variable	Factor	*df*	*F*	*P*
Aboveground biomass				
Community	Years	11	10.35	***
	Exclosure	1	10.47	*
	Years × exclusion	23	16.95	***
Monocotyledon	Years	11	12.26	***
	Exclosure	1	18.24	***
	Years × exclusion	23	14.96	***
Perennial dicotyledon	Years	11	12.26	***
	Exclosure	1	3.99	*
	Years × exclusion	23	3.25	***
Pioneer dicotyledon	Years	11	15.2	***
	Exclosure	1	0.76	ns
	Years × exclusion	23	28.68	***
Shrub	Years	11	2.5	ns
	Exclosure	1	7.11	**
	Years × exclusion	23	3.43	***
Species diversity (Shannon–Wiener index)				
Community	Years	11	9.18	***
	Exclosure	1	0.25	*
	Years × exclusion	23	5.06	***

ns not significant
*$P<0.05$; **$P<0.01$; ***$P<0.001$

In late August of 2002 to 2006, 2008, and 2010, interviews about nomadic pastoralism were carried out with local peoples who pasture livestock around the study site. Considering the answers, a period from September of the previous year to August of the current year was assumed as a nomadic fiscal year. Interview questions included (a) species and numbers of livestock managed in the previous nomadic physical year; and (b) distance traveled for livestock pasturing in the previous nomadic physical year. Livestock statistical information was provided by the National Statistical Office of Mongolia and the administration of Bayan-Unjuul County.

12.2.3 Data Analysis

According to the growth form and life history, plant species were classified into the following functional groups: (1) monocotyledons; (2) perennial dicotyledons; (3) annual dicotyledons; and (4) shrubs (Table 12.1). The palatability of species (Table 12.2) was categorized according to Yunatov (1968), Ulzykhutag (1985), Dashzeveg (1986), Ma (1994), Jigjidsuren and Douglas (2003), Eastern Oregon

Table 12.2 Numbers of species of different palatability among functional groups

	Palatability (number)			
	High	Moderate	Low	Unknown
Monocotyledon	9	1	–	–
Perennial dicotyledon	2	7	2	4
Annual dicotyledon	1	6	1	–
Shrub	2	–	1	–
Total	14	14	4	4

Sources: Yunatov (1968), Ulzykhutag (1985), Dashzeveg (1986), Jigjidsuren and Douglas (2003), Ma (1994), Eastern Oregon Agricultural Research Center (2005), Batjargal (2007)

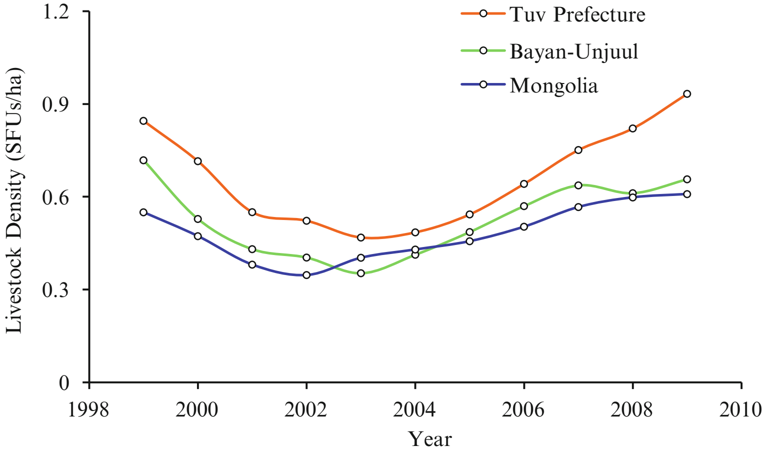

Fig. 12.1 Changes of livestock (sheep forage units, *SFUs*) intensity of Mongolia, Tuv Prefecture and Bayan-Unjuul County from1999 to 2009. Data from National Statistical Office of Mongolia (2004a, b, 2006, 2008, 2010), Administration of Bayan-Unjuul County

Agricultural Research Center (2005), and Batjargal (2007). Species diversity was evaluated using the Shannon–Wiener index. Analysis of variance (ANOVA) was applied to test for significant differences in aboveground biomass and Shannon–Wiener index among years and between Exclosure and Control sites.

Livestock densities were converted to sheep forage units (SFU) according to Tserendash (2000): 1 camel = 5.7 SFU, 1 horse = 6.6 SFU, 1 cattle = 6 SFU, 1 sheep = 1 SFU, and 1 goat = 0.9 SFU. During the study period, a severe cold disaster, called a “Zud,” caused extensive loss of livestock from winter 2002 to spring 2003 in Bayan-Unjuul (Fig. 12.1).

12.3 Results

12.3.1 *Variation of Aboveground Biomass Among Years and Effects of Livestock*

Aboveground biomass of the community and each functional group, except shrubs, showed significant annual variation (Table 12.1). Exclosure treatment had the strongest effect on the monocotyledon group, with relatively weak effects on shrubs and perennial species. There was no significant difference in dicotyledons between Exclosure and Control sites (Table 12.1), suggesting that grazing pressure was most concentrated on the dicotyledon species. The interaction of year and exclusion showed significant effects on aboveground biomass of the community and all functional groups.

12.3.2 *Relationship Between Aboveground Production and Grazing Intensity*

In 2000, 2005, 2008, 2009, and 2010, years that had comparatively high production, the aboveground biomass decreased significantly in the Control sites (Fig. 12.2). Aboveground biomass of monocotyledons and annual dicotyledons between Exclosure and Control sites was strongly correlated ($R^2=0.7032$, $R^2=0.6106$,

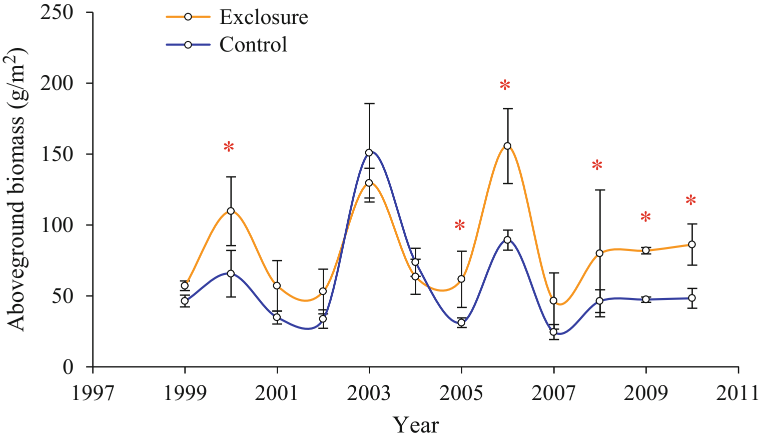

Fig. 12.2 Variation in aboveground biomass according to year and condition. *Dots* (mean ± SD, $n=4$) indicate values for Exclosure and Control sites. When the year × exclusion interaction was statistically significant, the repeated-measures analysis of variance (ANOVA) was followed by post hoc contrast tests for within-year comparisons. *Asterisk*: Statistical significance within each year at $P<0.05$. Data for 1999–2009 are from Nachinshonhor et al. (2009)

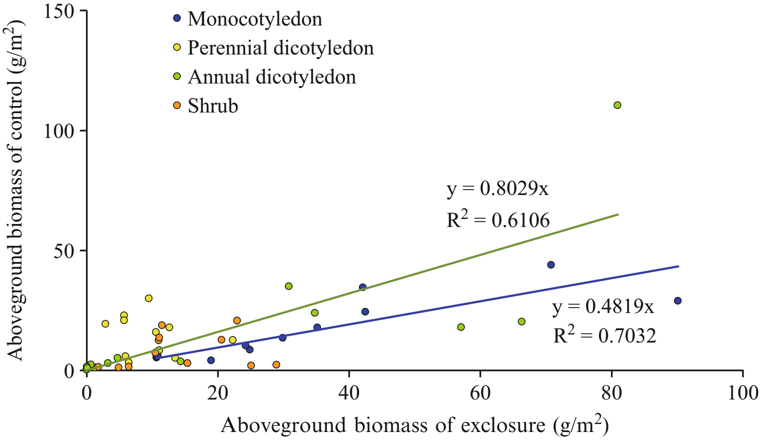

Fig. 12.3 Comparison of aboveground biomass of functional groups between Exclosure and Control sites. Regression lines show relationships for monocotyledon (*bottom*) and annual dicotyledon (*top*) groups. Data for 1999–2009 are from Nachinshonhor et al. (2009)

respectively), but for perennial dicotyledons and shrubs, there was no significant correlation (Fig. 12.3).

12.3.3 Variation in Species Diversity (Shannon–Wiener Index) Among Years and Grazing Pressure

The Shannon–Wiener index showed a significant annual variation (Table 12.1; $P < 0.0001$) and a weak but significant effect of exclosure (Table 12.1; $P < 0.05$). In terms of annual changes, species diversity significantly increased more in the Exclosure than in the Control site only in 2009 (Fig. 12.4; $P < 0.05$).

12.3.4 Relationship Among Nomadic Pastoral Mobility, Number of Livestock, and Aboveground Production

The interview results showed a trend indicating that annual migration distance increased with increasing numbers of livestock, with significant correlations found in four of seven cases (Fig. 12.5). Average annual migration distance differed significantly among years ($P < 0.0001$) and was correlated with aboveground production (Fig. 12.6; $R^2 = 0.4636$). Although this correlation was not significant, there was a significant difference between the longest migration, in 2003–2004, and the shortest migration, in 2007–2008 ($P < 0.001$).

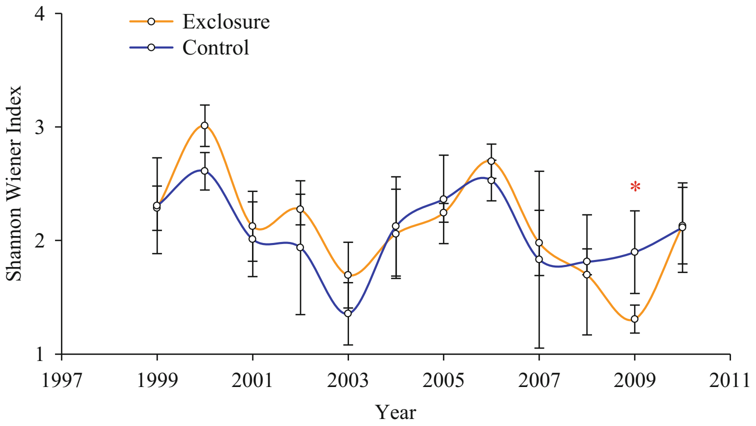

Fig. 12.4 Variation in aboveground Shannon–Wiener index according to year and treatment. *Dots* (mean ± SD, $n = 4$) indicate values for Exclosure and Control sites. When the year × exclusion interaction was statistically significant, the repeated-measures ANOVA was followed by post hoc contrast tests for within-year comparisons. *Asterisk*: Statistical significance within each year at $P < 0.05$. Data for 1999–2009 are from Nachinshonhor et al. (2009)

12.4 Discussion

12.4.1 Relationship Between Nomadic Livestock and Aboveground Production of Steppe Vegetation

The aboveground biomass in the Control site was strongly affected by livestock in the relatively high productivity years of 2000, 2006, and 2008–2010 (Fig. 12.2) as a result of grazing and trampling by livestock. This observation suggests that in years of limited production caused by adverse abiotic conditions such as drought events, the biotic effects of livestock were reduced. As a result, the vegetation escaped the double effects of abiotic and biotic damage. This natural control of grassland, with more feed in vegetation-rich areas, is based on the premise of free access to space and pastoral mobility. In this sense, the common use of land is important to Mongolian traditional nomadic pastoralism. The opposite case, limited mobility, which leads to degradation of natural vegetation, had been reported from Inner Mongolia (Wang 2006; Zhao et al. 2006; MunkhDalai et al. 2007), where traditional nomadic pastoral livestock management virtually stopped with the introduction of land policies dictating semi-privatization.

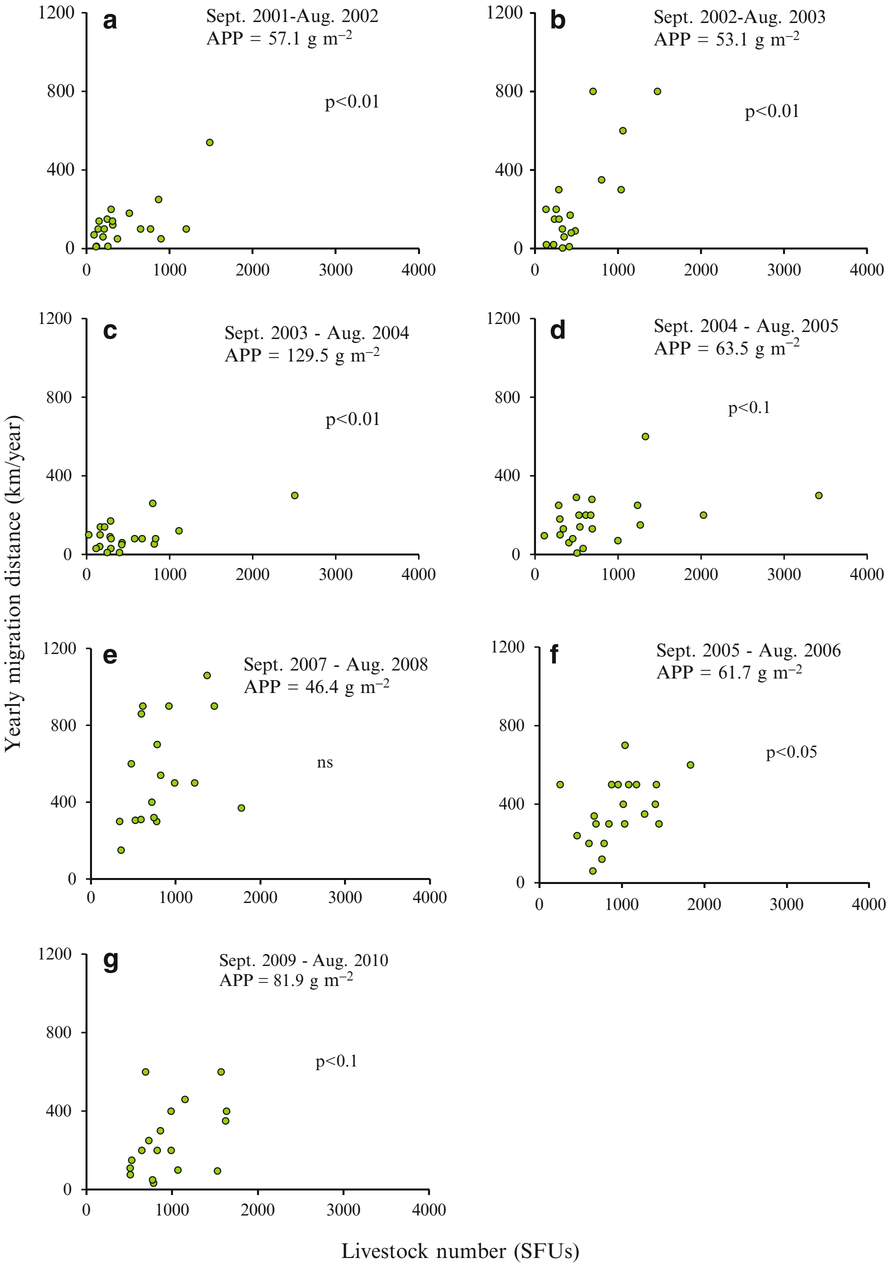

Fig. 12.5 Relationship between livestock numbers (SFUs) and yearly average migration distances was significantly different during the study period ($P<0.001$). Data for 2001–2009 are from Nachinshonhor et al. (2009)

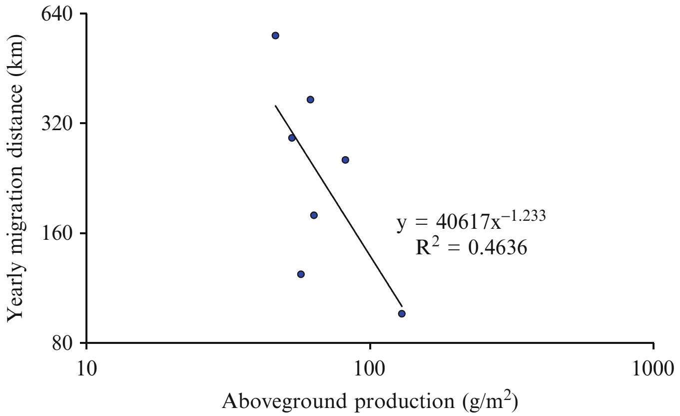

Fig. 12.6 Relationship between aboveground production of the plant community and average yearly migration distance for nomadic pastoralists (log scale: 2002, $n=22$; 2003, $n=20$; 2004, $n=20$; 2005, $n=22$; 2006, $n=22$; 2008, $n=23$; 2010, $n=18$. Data for 2001–2009 are from Nachinshonhor et al. (2009)

12.4.2 Effects of Nomadic Pastoral Herding on Species Composition of the Plant Community

Ulzykhutag and Dariimaa (1977) showed that graminoids, such as xerophilous species, and shrubs dominate this region and also noted the important role of these plants for the local nomadic pastoral livestock industry. All monocotyledons in our site were palatable to livestock (Table 12.2), especially *A. cristatum*, *S. krylovii*, and *Allium* spp. Local nomadic people call these plants "Nariin Nogoo" or "Nariin Övs" in Mongolian, which means "fine plants" (G.U. Nachinshonhor, personal communication). The same names were reported by Kakinuma et al. (2008) from the Mongolian forest steppe. Compared with monocotyledons and shrubs, perennial dicotyledons showed a slight but significant decrease in the Control site, possibly because they were dominated by unpalatable species such as *A. adamsii* (Table 12.2; Eastern Oregon Agricultural Research Center 2005). Palatable species such as *Artemisia frigida* and *Convolvulus ammanii* made only a weak contribution to the community.

12.4.3 Relationship Between Species Diversity and Nomadic Pastoral Herding

We observed that in 2003, 2008, and 2009, relatively wet years following heavy drought events, some pioneer species such as *Chenopodium* spp. increased greatly (data not shown), as also reported by Yunatov (1976). The mass-generating pioneer species had reduced species diversity in these years (Fig. 12.4). Although species diversity was lowest in 2009, the Control site had a significantly higher Shannon–Wiener index than did the Exclosure site. In contrast to these results, a study in Inner Mongolia showed that species diversity significantly decreased after heavy grazing (Zhang et al. 2004. Our result showed that grazing can increase species diversity (Shannon–Wiener index; Table 12.1, Fig. 12.4), suggesting that a switch in grazing affects the vegetation composition and is related to management regime.

12.4.4 Some Lessons from Interviews on the Sustainability of the Steppe Ecosystem and Nomadic Pastoralism

After two successive years of heavy drought (2001 and 2002), a disastrous winter Zud occurred during winter 2002 to spring 2003 in Bayan-Unjuul. As a result, by the end of 2003, the livestock numbers (SFUs) had decreased by about 12.5% compared with the end of 2002, and the density dropped to the lowest value measured during the study period (Fig. 12.1; National Statistical Office of Mongolia 2004a, b, 2006, 2008, 2010). Despite high production in 2003, the decrease in livestock density reduced the grazing pressure in 2003 (Fig. 12.2). The reduction in livestock numbers and the high vegetation production may have led to relatively less mobility from September 2003 to August 2004 (Fig. 12.5c).

Interview results showed that grazing intensity was regulated by migration distance, which was adapted to vegetation production (Fig. 12.6). Although this relationship was not significant, the average migration distance was significantly different between the longest and shortest migration years during the study period, and the production of plant communities between these years was also significantly different ($P<0.05$), which suggests that annual migration patterns were adapted to the productivity of the steppe communities.

Noboru et al. (2009) showed that, in relatively arid conditions, continuous grazing pressure over long periods not only reduces the quantity but also changes the quality of plant communities. Although a clear decrease in species diversity after livestock grazing was not shown, our study supports the idea that grazing intensity regulation will contribute to the sustainability of steppe vegetation. Nomadic herders know that they cannot change nature (weather), but they can move livestock to avoid difficult conditions, and this mode seems to be the most basic principle of nomadic pastoralism. Interview results further suggested that the benefits of nomadic pastoralism lie not only in obtaining food for livestock but also in assuring the health of livestock through their movement. Feedback systems between steppe vegetation and nomadic pastoralism contribute to sustainability of both human society and the natural environment of the nomadic pastoralist Mongolian region.

Acknowledgments I thank Dr. T. Hirose, Dr. L. Jargalsaikhan, Sh. Dugarjav, Tserendash, Tsooj, Tuvshintogtokh, and the many people who invested their time and energy to make this research possible. This research was supported by the Social Welfare Corporation NANKO AIRINKAI, Institute of Botany of the Mongolian Academy of Science, Tohoku University Graduate School of Science, Tohoku University Study Center for North East Asia, the Japan Science Society, Tokyo Metropolitan University, Meiji University, the Toyota Foundation, Niigata University, the Arid Land Research Center of Tottori University, the Japan Society for the Promotion of Science, the National Museum of Ethnology, and the Research Institute for Humanity and Science.

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