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GIS Analysis of Grazing Selection by Goats in Tov Province, Mongolia

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Abstract: In Mongolia, the rapid grassland degradation induced by overgrazing in these years is assumed to worsen the disaster called *dzud*. In this study, we attempted to monitor the grazing behavior of flock of goats in connection with the vegetative and topographic environments in Mongolian grassland. From the results of the GIS analysis, goats' movement in the grazing situation is found out to be less than the velocity of 4 km h^{-1} and the mode value to be ca. 0.4 km h^{-1}. Slight correlation (r=0.67) of the grazing velocity with NDVI value was found.

Keywords: Goat, GPS, Grazing selection, Mongolia, NDVI

1. Introduction

Mongolian grasslands experienced severe livestock losses (more than 5 million livestock) due to harsh winter disasters called *dzud* in 2000 and 2001. The rapid grassland degradation induced by overgrazing in these years (Kawamura *et al*., 2005) is assumed to worsen the disasters (Shimada *et al*., 2007). Within the six years of between 1993 and 1999, the total number of livestock had increased more than 8 million in Mongolia. Moreover, the change in the livestock composition, especially the increase in goat breeding is obvious in Mongolia. The total number of goat livestock has surpassed that of sheep since 2003 (ca. 13 million goats in 2006) owing to the cashmere's industry establishment as a major export product. However, the goats have negative impact on grassland due to their natural grazing behavior which involves uprooting the vegetation. In this study, we attempted to monitor the grazing behavior of flock of goats in connection with the vegetative and topographic environments in Mongolian grassland.

2. Materials and Methods

Portable GPS receivers (Garmin eTrex and Geko201) were set on the goats' back (**Fig. 1**) during the daytime for each observation in order to track their grazing movement. We collected 9 GPS tracking datasets taken in summer time during the year of 2003 – 2007, mostly from Tov Province in Mongolia (**Fig. 2**). The tracking intervals were set to be 30 second (except Plot S1 and S2), but they varied dependent on the position of GPS sensor. The tracking latitude, longitude and time were recorded in the GPS logger. Total tracking distance, duration and speed were calculated from the tracking records. The tracking points were, then using GIS, overlaid onto satellite imageries (**Fig. 3**) and topographic data in order to trace goats' grazing selection from the vegetation and geomorphologic information, respectively (**Table 1**). Average moving velocity value of goats for each plot was calculated by dividing

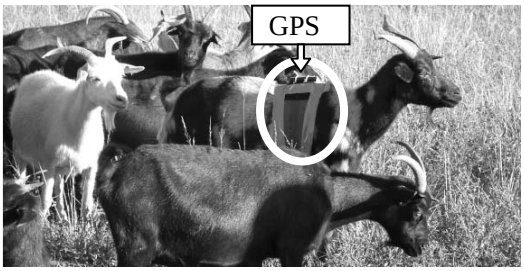

Fig. 1. GPS receiver attached Goat.

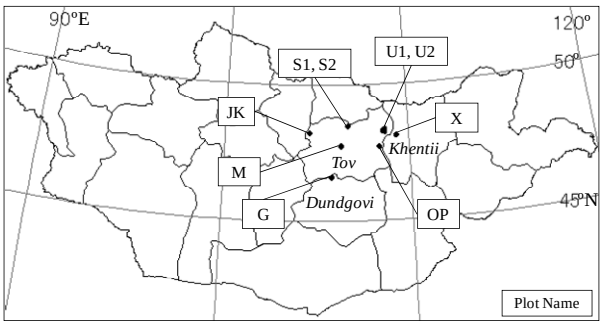

Fig. 2. Location of the GPS tracking plots in Mongolia.

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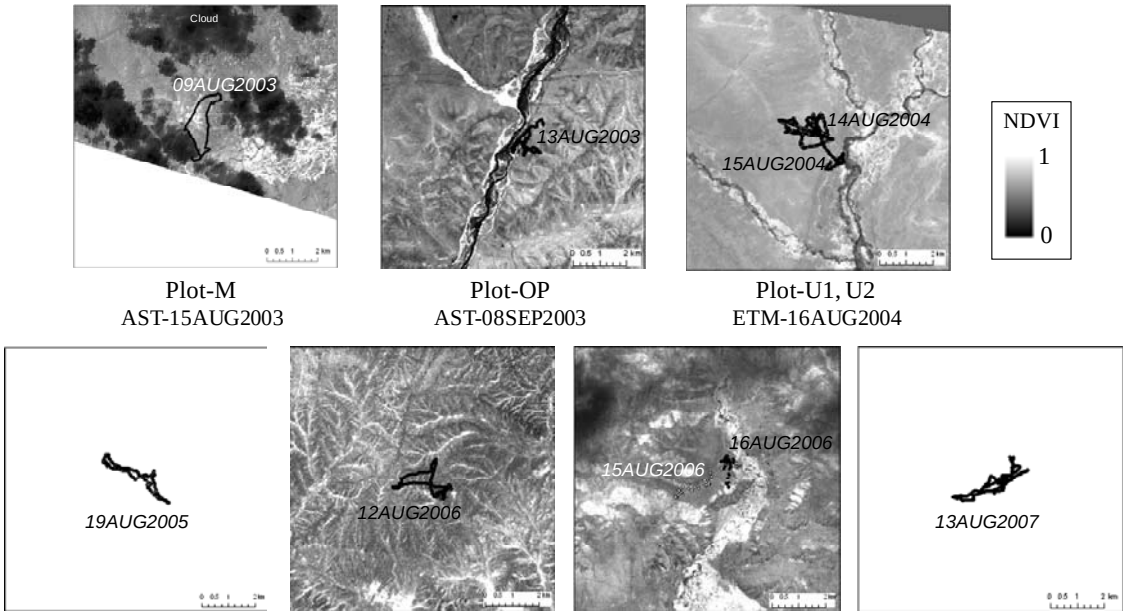

Fig. 3. Satellite imagery (NDVI) used for each plot analysis (except Plot-JK and X) superimposed by the GPS tracking points.

total tracking distance by the tracking duration. Mode value of the velocity was derived by observing the frequency chart for each plot.

Five satellite imagery scenes (viz. Terra-ASTER, Landsat-TM and –ETM+) that cover tracking plots at corresponding date to the observations were obtained (Table 1). ASTER and Landsat data were obtained from ERSDAC (http://www.ersdac.or.jp/) and USGS EarthExplorer (http://edcsns17.cr.usgs.gov/), respectively. NDVI values from each image were calculated by the following equation:

$$NDVI = (DN_{red} - DN_{NIR}) / (DN_{red} + DN_{NIR}),$$

where DN_{red}: digital number of red band, DN_{NIR}: digital number of near-infrared band.

SRTM-DEM data were used to clarify the topographic characteristics of the grazing plots. SRTM-DEM data were acquired via USGS EarthExplorer. The topographic information on the goats' tracking points for each plot, such as altitude values with the variety in altitude values (Table 1), slope and aspect were extracted from the SRTM-DEM.

Correlation analyses were conducted both between goats' moving velocity and vegetative parameter (i.e., mean NDVI) among 7 available plots and between goats' moving velocity and topographic

Table 1. Tracking information, location, and corresponding satellite image of the 9 tracking plots.

Plot name	Number of GPS point	Date	Total tracking distance (km)	Total tracking duration (h)	Center of the plot		Altitude (m)	Corresponding Satellite image
					Latitude (N)	Longitude (E)	Mean ±SD	
M	514	09AUG2003	8.02	6.27	47º 43' 54"	106º 21' 33"	1210 ±41.9	AST, 15AUG
OP	516	13AUG2003	6.06	6.55	47º 40' 16"	108º 27' 50"	1311 ±22.0	AST, 08SEP
U1	947	14AUG2004	6.64	6.80	48º 13' 14"	108º 37' 40"	1400 ±8.8	ETM, 16AUG
U2	1449	15AUG2004	13.80	12.00	48º 13' 28"	108º 37' 03"	1415 ±9.6	ETM, 16AUG
JK	1017	19AUG2005	9.50	10.94	48º 13' 20"	104º 38' 23"	1410 ±85.2	No data
G	1063	12AUG2006	9.40	8.80	46º 35' 59"	105º 49' 56"	1646 ±23.8	TM, 12AUG
S1	33*	15AUG2006	5.50	4.05	48º 28' 32"	106º 47' 17"	1098 ±27.9	TM, 12AUG
S2	29*	16AUG2006	6.26	5.12	48º 28' 14"	106º 46' 42"	1115 ±30.6	TM, 12AUG
X	1237	13AUG2007	12.88	13.89	48º 04' 53"	109º 21' 10"	1367 ±34.8	No data

* GPS track saving interval was set to be 10 minutes for Plot-S1 and S2.

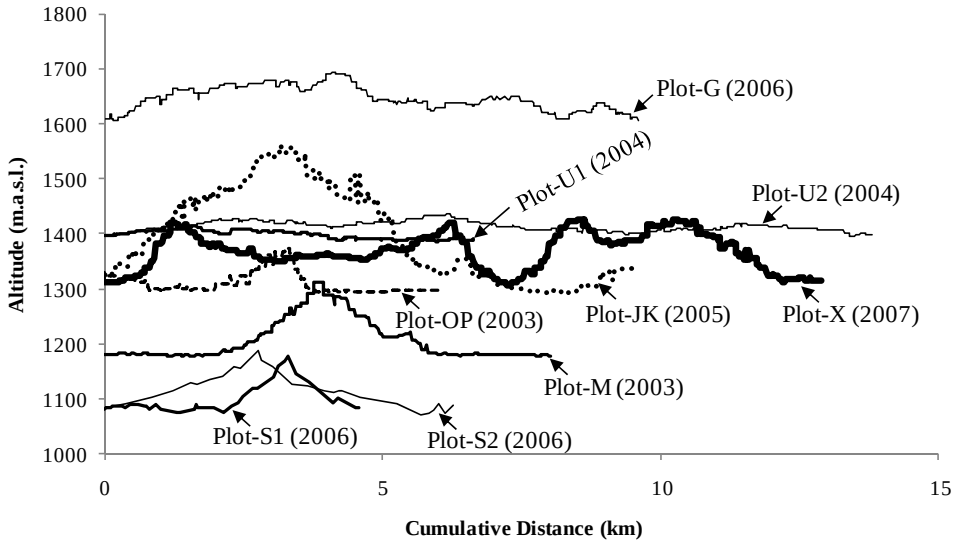

Fig. 4. Comparison of altitude versus distance chart of goats' movement between each tracking plot.

parameters (i.e., mean altitude, mean slope) among 9 plots.

3. Results and Discussion

According to the analysis results of the GPS tracking data from each plot, total distance of goats' movements varied from ca. 6 – 14 km (Table 1). The mode values of moving velocity ranged between 0.1 – 0.8 km h^{-1}, and the values of total tracking distance per duration ranged between 0.87 –1.36 km h^{-1} (**Table 2**). **Fig. 4** shows the altitude versus distance chart for each tracking plot. This chart indicates that the flock of goats likely to select to climb on hills up to relative height of ca. 100 m. This tendency can be seen at most of the plots (except Plot-U1, U2 and G). The cumulative proportion of frequency in the degree of moving velocity from 9 tracking plots is shown in **Fig. 5**. This result shows that goats' movement in the grazing situation is mostly less than the velocity of 4 km h^{-1} (occupies 88% of the total) and the mode value is ca. 0.4 km h^{-1} (moving velocity of the range between 0.3 – 0.4 km h^{-1} occupies 4% of the total). Goats' moving velocity of the range between 0 – 0.5 km h^{-1} occupies 20% of the total.

Slight correlations were found between average moving velocity and mean NDVI value (r=0.57), and between mode moving velocity and mean NDVI (r=0.67) (**Fig. 6 (A)**). However the both correlations were not statistically significant (P>0.05), above results indicates that goats tend to move relatively rapid when the grazing environment is rich (i.e., mean NDVI of over 0.3), while relatively moderate when poor (i.e., mean NDVI of lower than ca. 0.2). Slight negative correlations were found in average moving velocity versus mean slope (r=-0.60) (**Fig. 6 (B)**) and in average moving velocity versus mean slope

Table 2. Goats' behavior, topographic and NDVI characteristics from the 9 tracking plots.

Plot name	Average moving velocity (km h^{-1})	Mode moving velocity (km h^{-1})	Mean Slope (degree)	Distribution of Aspect (%)			NDVI
				North	South	Others	Mean ±SD
M	1.28	0.4	3.14	25.4	43.0	31.6	0.13 ±0.09
OP	0.92	0.1	4.35	42.0	13.2	44.9	0.12 ±0.08
U1	0.98	0.5	1.17	42.3	24.3	33.4	0.28 ±0.10
U2	1.15	0.4	1.22	16.7	50.2	33.1	0.30 ±003
JK	0.87	0.3	10.19	38.2	19.4	42.4	-
G	1.07	0.2	4.45	14.3	74.5	11.1	0.20 ±0.06
S1	1.36	0.4*	3.37	55.9	0.0	44.1	0.49 ±0.05
S2	1.22	0.8*	3.94	63.3	20.0	16.7	0.45 ±0.09
X	0.93	0.3	5.02	29.7	60.0	10.3	-

* GPS track saving interval was set to be 10 minutes for Plot-S1 and S2.

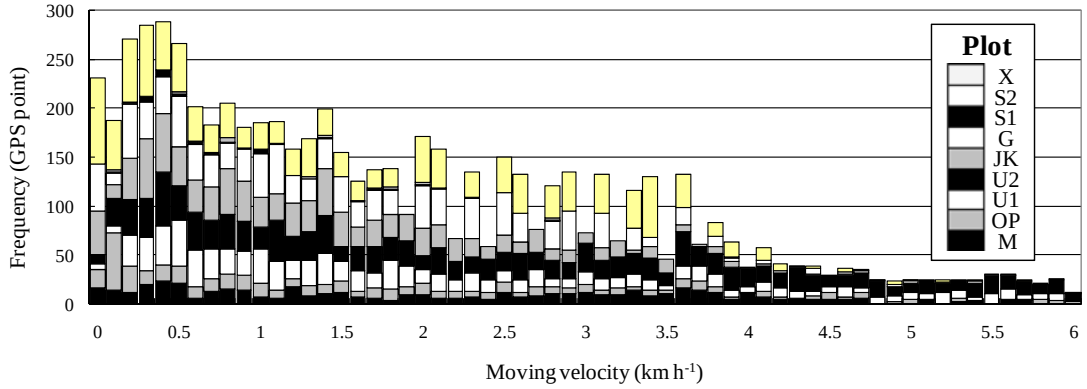

Fig. 5. Cumulative proportion of frequency in the degree of moving velocity from 9 tracking plots.

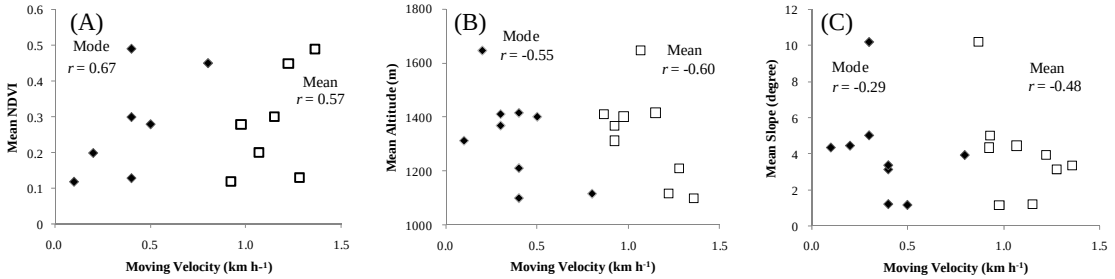

Fig. 6. Relations of (A) NDVI versus moving velocities, (B) altitude versus moving velocities (C) slope versus moving velocities among tracking plots.

(r=-0.48) (**Fig. 6 (C)**). However, the correlations were not significant (P>0.05) and there seems no effective explanation for the relation between grazing selection and topographic environment.

4. Conclusions

In this study, we found out that the vegetative environment affects goats' grazing behavior but could not found out good correlation between goats' behavior and topographic environment. Our findings are as below:

(1) The grazing movement velocity of the flock of goats is ranged between 0.87 – 1.36 km h^{-1} in average and mostly in the velocity of between 0 – 0.5 km h^{-1}.

(2) Rich vegetative environment (i.e., high mean NDVI) tends to accelerate the velocity of grazing movement of the flock of goats. The reason for this may be that goats don't have to take time to select for grazing under the rich vegetative condition.

We still need to analyze how do multiple factors of vegetative and morphological environment affect goats' grazing selection in order to predict their behavior and the effect of over grazing.

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