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Patterns of grazing behavior of livestock in settlements of Inner Mongolia

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内モンゴルの定住型放牧地における家畜の食草行動パターン

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1. Introduction

Fragile semi-arid grassland is very sensitive to climate change and overgrazing. Recently, rapid land degradation and desertification have been disturbing the steppe grassland of Inner Mongolia, which covers an area of up to 79,100,000 ha, and one of the largest remaining grassland ecosystems in the world (Li, et al., 2000). The land degradation and desertification in Inner Mongolia pasture land, resulted from various factors, such as climatic variation and human impacts. In recent years, influences of human factors, such as overgrazing due to the increase in livestock numbers, are accelerating natural processes of land degradation and desertification in Inner Mongolia pasture area (Hoshino, et al., 2009). The mean available land area for one sheep has decreased from 6.8 ha in the 1950s to 1.6 ha in the 1980s (Yiruhan, et al. 2001).

During last 60 years, the land use policy from government of China had a significant impact on husbandry regions in Inner Mongolia. Sharing the land was carried out according to the establishment of People's Commune in 1958. But 20 years after, the livestock and land was distributed from People's Commune to each family having house-hold by the introduction of Household-responsibility system.

After that a new method for the management of pastures using construction of fences and settlement of nomad were appeared in throughout the Inner Mongolia. But the emergence of fences has restricted movement of nomad and livestock and forced them to use the same kind of pasture all year around. The pastures are quickly overgrazed and contributed to heavy degradation and desertification (Hoshino, et al., 2009). However, it is not clear the behavior of livestock after the settlement.

The purpose of this research is to understand the patterns of grazing behavior of livestock in settlements of Inner Mongolia.

2. Materials and Methods

2.1 Study area

The study area was located in Abag steppe, Xilingol Aimag, Inner Mongolia, China (Fig. 1). The latitude was 43°04′-45°26′N and the longitude was 113°27′-116°11′E. The average altitude is 1130m. The mean annual temperature is approximately 3℃; Annual precipitation is less than 300mm, and increased from northwest to southeast (Fig. 2). Dominant plant communities consist of *Leymus chinensis, Stipa grandis and Stipa kryovii.*

We select four sites (families) in Abag steppe

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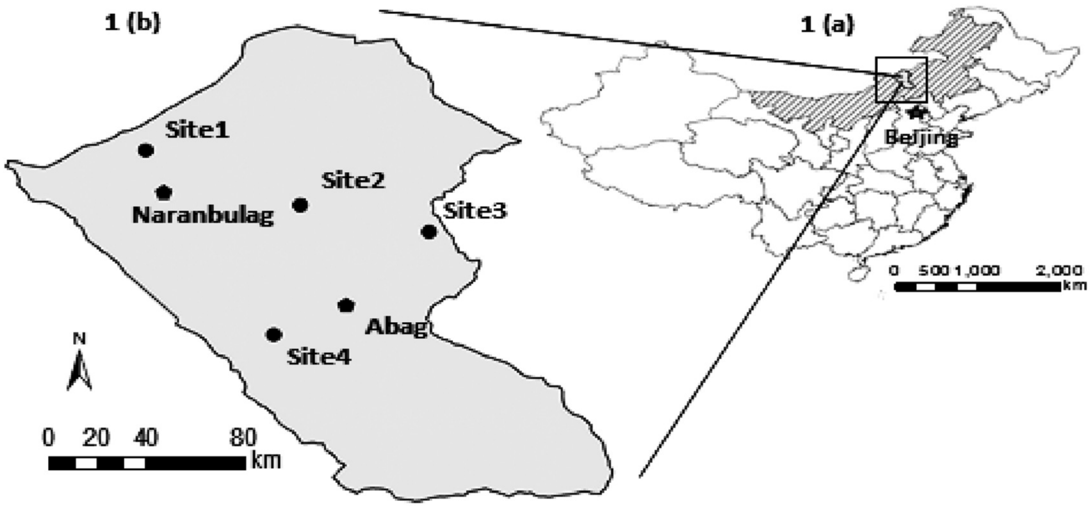


Fig. 1 Location of the study sites (a) map of the China; (b) County of Abag, Inner Mongolia, China

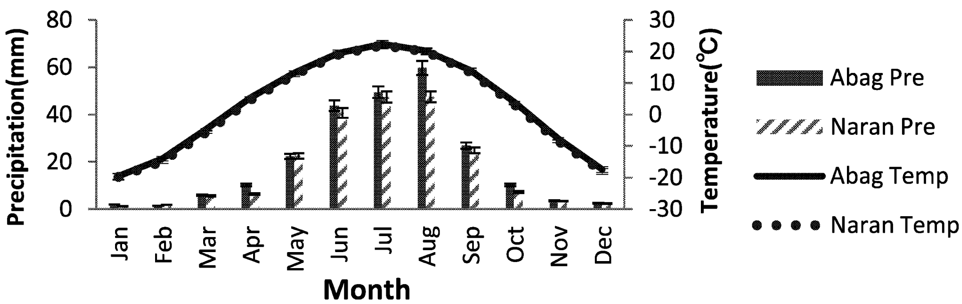


Fig. 2 Monthly precipitation and air temperature of Abag and Naranbulag (2001～2010)

Table 1 Livestock number and pasture land area of four sites in study area

Site no	Owner	Livestock number (n)			Pasture area (km^2)
		Sheep (including Goat) (n)	Cattle (n)	Horse (n)	
1	Borhuu	600	60	0	12.0
2	Baljinima	500	15	0	8.7
3	Nabchi	600	35	0	12.0
4	Chebelma	200	16	2	10.7

according to the changes of precipitation and grazing intensity, and then fitted the GPS data Logger (DG-100) to sheep. The livestock number and area of each site are showed in Table 1.

2.2 Methods

2.2.1 Satellite tracking of livestock

One sheep from each of the four groups was fitted with GPS logger using hand-made belts two days. From July 12 to 13, 2011 in site 1, from July 16 to 17, 2011 in site 2, from July 19 to 20, 2011 in site 3, from July 22 to 23 in site 4 (Fig. 3). Information regarding sheep positioning from the GPS was collected every 10 seconds and location signal was stored up during grazing. In the evening after grazing, the data including: ① date ② time ③ traveling distance ④ speed ⑤ location (latitude/longitude) was downloaded to a computer. Using geographic information system (GIS) software (ArcGIS 10, ESRI) converted coordinates to Universal Transverse Mercator (UTM) form to facilitate algebraic derivation of total distances and total areas.

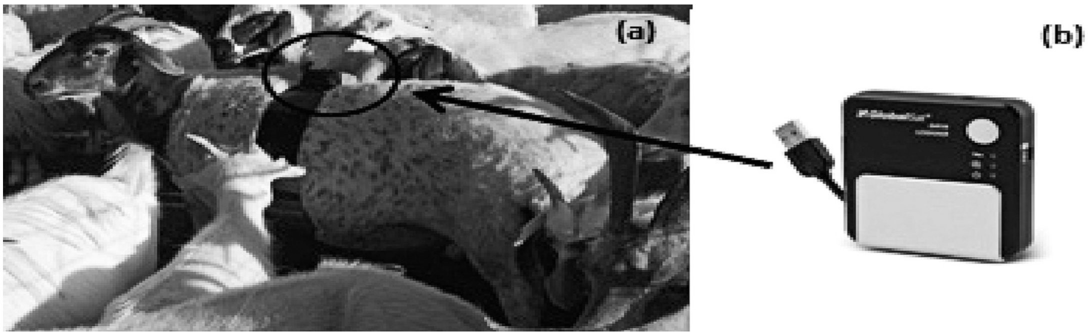


Fig. 3 Fixing the GPS data logger onto the sheep using a hand-made belt (a) picture of sheep fitted with GPS data logger; (b) GPS instrument

2.2.2 Satellite data analysis

2.2.2.1 Landsat data

The satellite data come from Landsat TM images taken in August 09, 2011 were used to calculate SAVI by software ENVI (©ITT). In areas where vegetative cover is low and the land surface is exposed, the reflectance of light in the red and near-infrared spectra can influence vegetation index values. The soil-adjusted vegetation index (SAVI) was developed as a modification of the normalized difference vegetation index (NDVI) to correct for the influence of soil brightness when vegetative cover is low. The SAVI is structured similar to the NDVI but with the addition of a soil brightness correction factor. The higher value of SAVI means vegetation is better and more healthy.

$$SAVI = \frac{NIR\text{-}RED}{(NIR + RED + L)} * (1 + L) \qquad (1)$$

In Eq. (1), NIR is the reflectance value of the near infrared band, RED is reflectance of the red band, and L is the soil brightness correction factor. The value of L varies by the amount or cover of green vegetation: in very high vegetation regions, $L=0$; and in areas with no green vegetation, $L=1$. Generally, an $L=0.5$ works well in most situations and is the default value used. When $L=0$, then SAVI = NDVI. In this study we taken the value $L=0.5$.

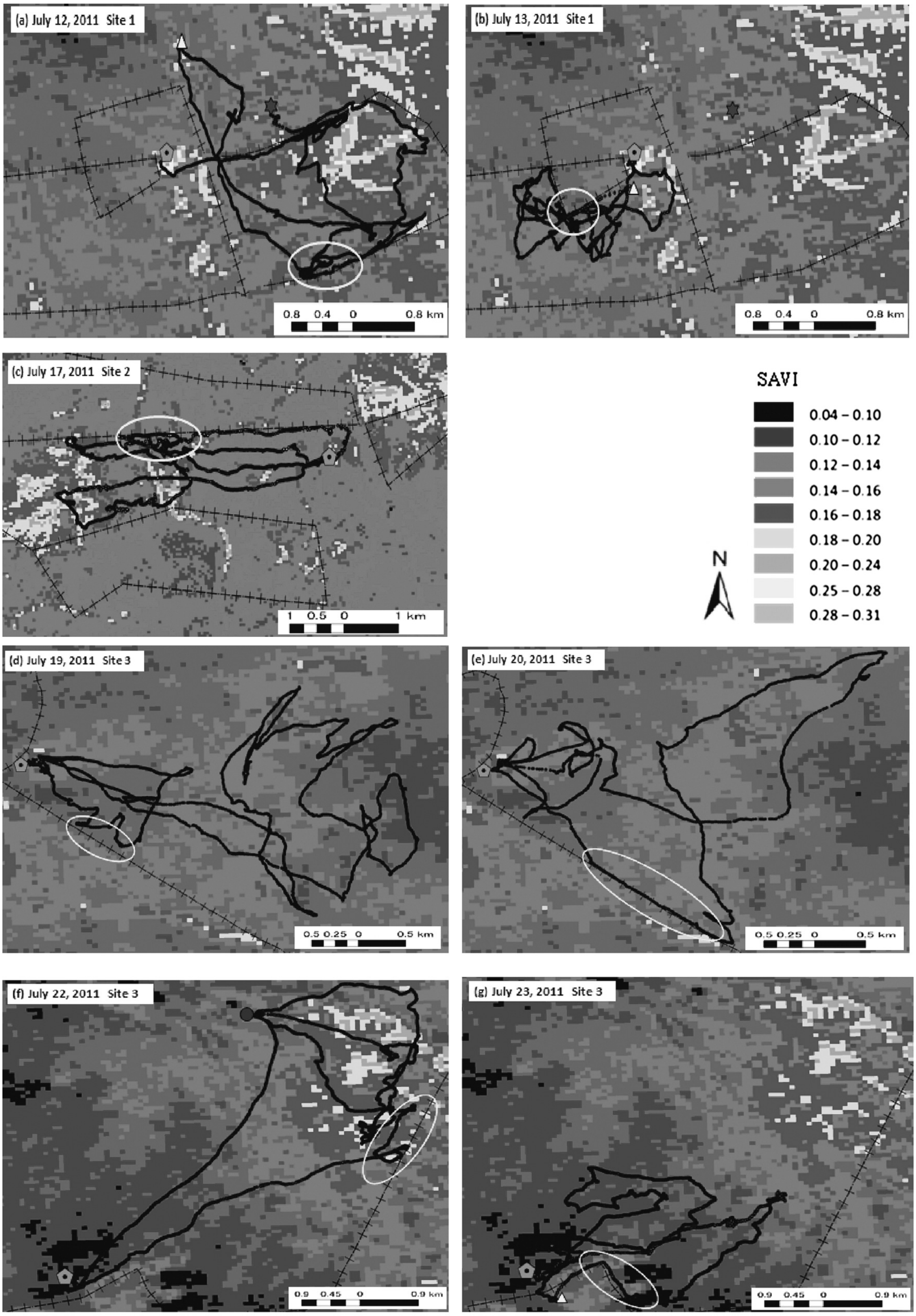
2.2.2.2 ASTER DEM data

ASTER Digital Elevation Model (DEM) data of the study area which taken in Febrary 28, 2011 was used to understand the land form after topographic by ENVI. In this study, the slope, aspect and altitude were uesd to know the landform of the grazing area.

3. Results

3.1 Daily traveling of sheep

Over the 8days study period, 7 of the 8 GPS functioned well except July 16, 2011 in site 2 due to battery shutoff. Because of the short battery life, battery has to be charged every day. The daily tracking of each sheep group is shown in Fig. 4. As the figure shows during grazing time all sheep went to well or come back to near the house to drink water once a day. Sometime sheep were supplied with drinking water from a water pool after a rainfall, such as Fig. 4f on July 22. In site 1 and 4, there had wells nearly, but site 2 and 3 the well is so far that the people carried drinking water from well every day by truck. During the grazing time, in all sites most of the signals were located where the SAVI value is relatively higher place, but not the highest place (Fig. 5). The highest SAVI value appeared near the house or well, resulted from bush and some grasses growing higher, but these grasses were not palatable for sheep. In site 2, the surrounding area of house was used during summer time and the west is used for winter pasture. Although no fences between them to restrict the sheep moving, but if sheep group moved into the winter used pasture, nomad would get them out. So all sheep moved along the route where grass is better and palatable. But the grazing range and distribution were restricted because of the fences, sometime caused sheep go to the same place for two times (Fig. 4(a)). The data obtained from



: House : House only used in summer time (from Jun to Aug) △: Well ●: Water pool

-·-+-+-·-: Fence

Fig. 4 Traveling routes of sheep in four sites on Landsat TM5 SAVI (Aug, 9 2011)

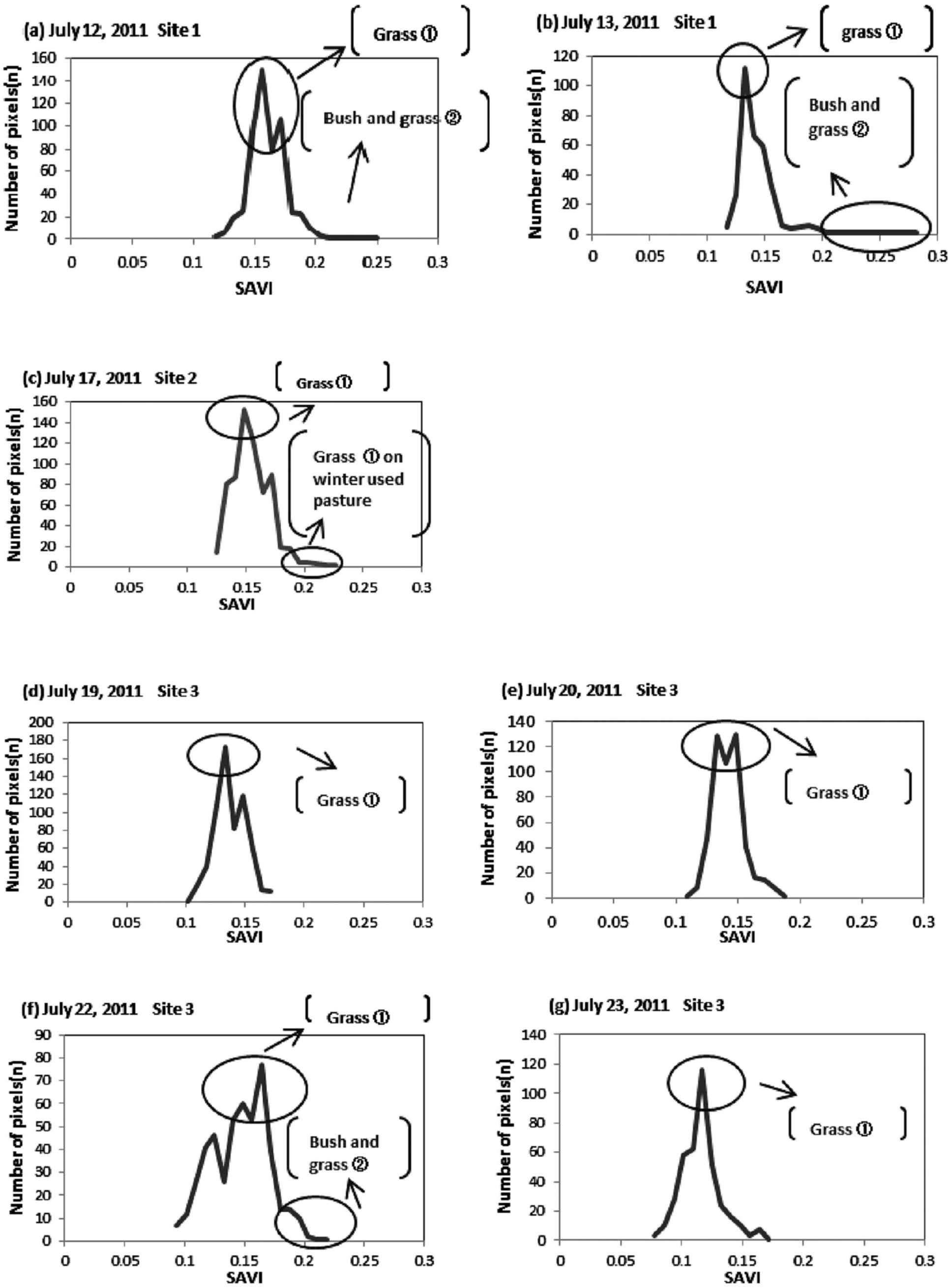


Fig. 5 Sheep footprint detected by SAVI pixels (30m×30m) data. Grass ①: grass palatable for sheep, such as: *Stipakryovii, Leymus chinensis* and *Agropyron*; Grass ②: grass not palatable for sheep but grow higher, such as: *Chenopodium acuminatum, Caraganaa and Psammochloa villosa (Trin) Bor*

GPS logger is showed in Table 2.

3.2 Influence of landscape factors (slope and aspect) on grazing distribution

Several factors have been identified as important influences on grazing distribution (Brock and Owensby, 2000), for example pasture size, slope, and proximity to fences, weather, and distance to well water and so on. GPS footprint data show that grazing sheep are used slopes with less than 10° (Fig. 6); mean sheep would like to move in the area of shallow slope. During 7 days, the longest traveling distance occurred on July 17th, where the mean value of slope is faintest. And both in site3 and 4, according to the slope traveling distance were changed. But in site1 the distance to

Table 2 The pattern of grazing behavior of sheep in study sites based GPS traveling

Time	Traveling time (h)	Traveling area (km²)	Traveling Distance (km)	Mean Traveling Speed (km/h)
July 12 2011	14.15	2.23	18.44	1.30
July 13 2011	13.27	0.74	11.42	0.86
July 17 2011	11.27	2.45	26.03	2.31
July 19 2011	13.88	2.41	19.35	1.39
July 20 2011	12.68	2.60	14.64	1.16
July 22 2011	14.43	2.44	14.53	1.01
July 23 2011	14.50	1.21	13.96	0.96

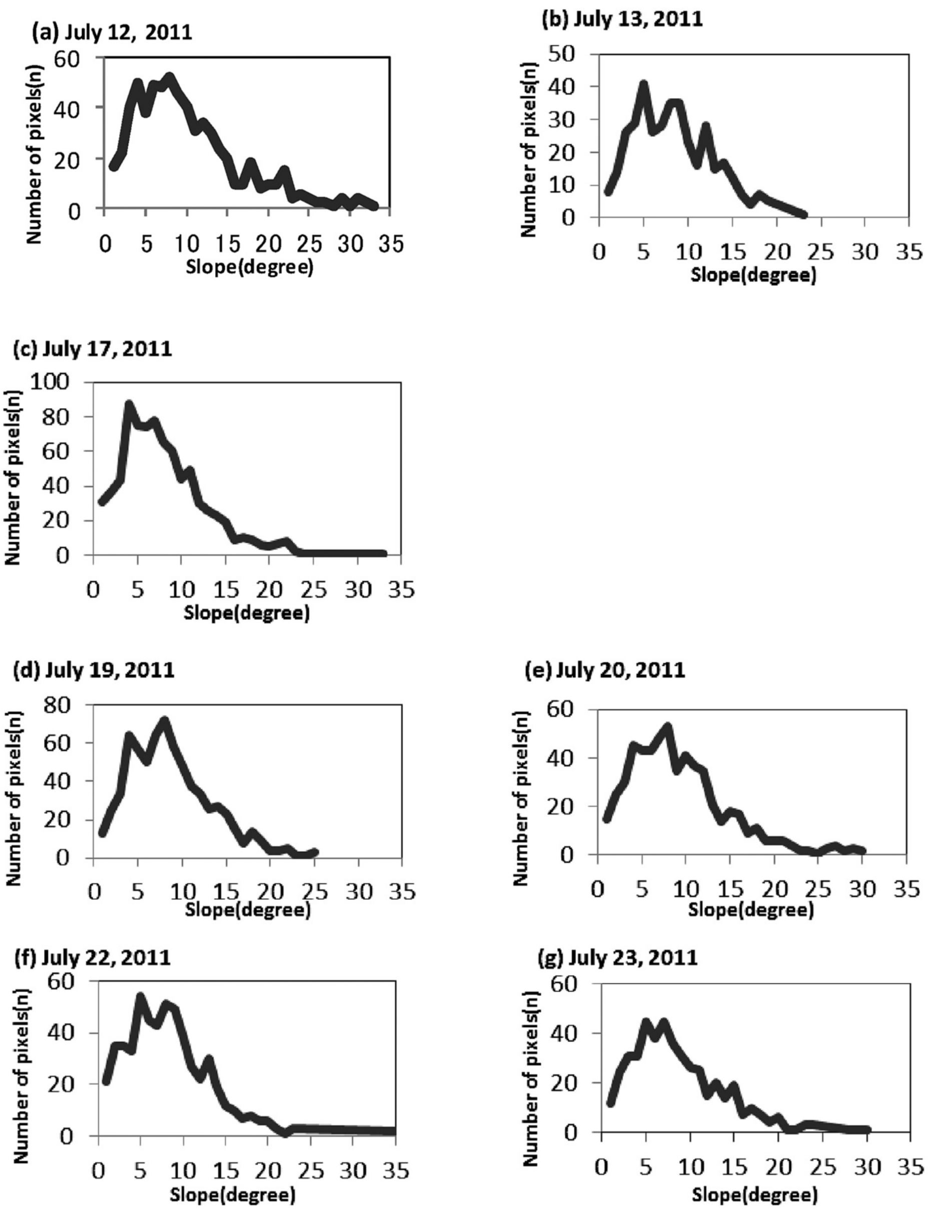


Fig. 6 Slope for pixels where signal points were located

water is an impact factor than slope in this case (Table 3).

The result of the aspect from pixels is shown in Fig. 7. Most of the pixels where signal points were detected were located in the south or west where grass is better than that of north in others.

Table 3 Slope and traveling distance in four sites

	Site 1		Site 2	Site 3		Site 4	
Data	12	13	17	19	20	22	23
Slope (degree)	10.1	8.4	8.0	8.8	9.4	8.4	8.6
Travling Distance (km)	18.4	11.4	26.0	19.4	14.6	14.5	14.0

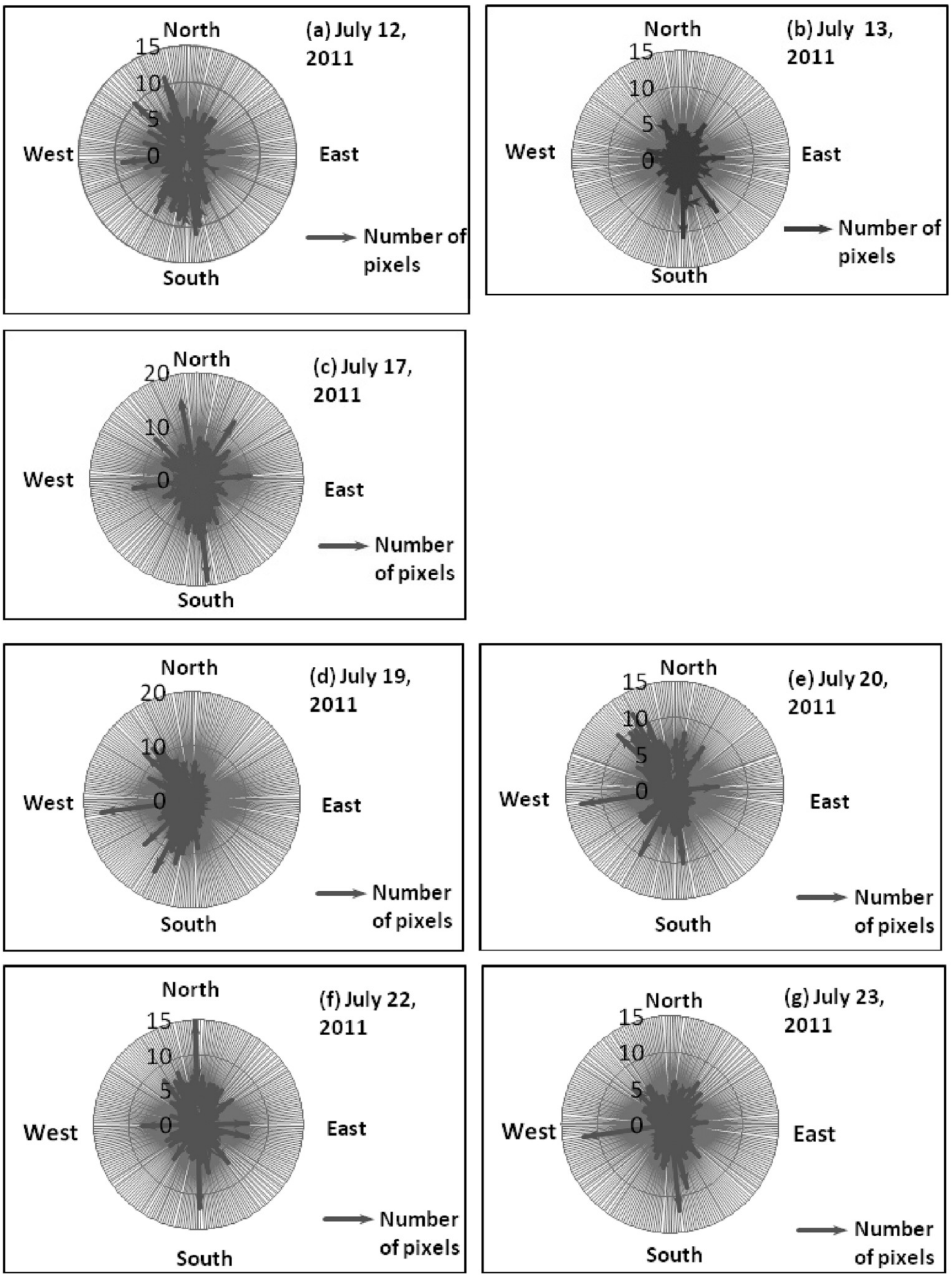


Fig. 7 Aspect for pixels where signal points were located

But not only had the grass, water place, settled house also impacted the distribution of grazing in this study as shown in Fig. 7.

3.3 Result of the counting of location points in each pixel of Landsat image

We counted the location signal points (stored up every 10 seconds) in each pixel (30 m×30 m) to try

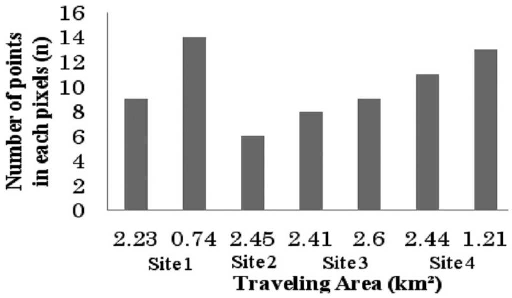


Fig. 8 Traveling area with numbers of ground points in pixels

to estimate the grazing intensity. According to Fig. 8 where the traveling area was smallest (0.74 km^2, site 1) there was the highest value (14 points) of mean number of points in pixel. And to the same sheep group same tendency was showed in site 1, site 4. Both in site 1 and 4, the traveling area of 2 days had obvious difference. So in the restricted and smaller area, sheep repeat the route all day or located one place long time. If this usage of grassland contained long term, it would contribute crowded pastures were quickly overgrazed and grassland were deserted.

4. Conclusions and discussions

The results of this study show that a combination of satellite data with GPS/GIS is an effective tool for quantifying grazing distribution in Inner Mongolia. It has been found that, the grazing distribution of sheep is effected by slope, aspect and distance to water, and also by settlement of nomads and emergence of fences. The latter are restrict the movement of the sheep, resulting in chaotic movements inside enclosed area. So far such movement would increase grazing intensity on per unit pasture and accelerate the land degradation.

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和 文 要 約

中国内モンゴル自治区では，1980 年から政府の生産労働責任制の導入により，定住化が進み，それに伴い，定住を始めた元遊牧民たちはほかの家畜を入れないため，また冬季に家畜に食べさせる草を確保するために個人が使用する土地を柵で囲んだ。私たちは定住化が相当に進んだ内モンゴル自治区シリンゴルアイマッグの家畜の行動パターンを明らかにするため，2011 年の 7 月に当アイマッグのアバガ旗で羊に GPS を装着し，羊の追跡調査と放牧地におけ

る植生の現地調査を行った。その結果，家畜の行動は地形，水場からの距離，柵，放牧地の面積に影響されていることがわかった。さらに，昔からの遊牧と変わって，定住化が進んだ今の内モンゴルでは，牧民と家畜が毎年同じ場所を繰り返し利用した結果，小範囲での過放牧が進み，最終的に草原の退化と砂漠化を招いたと考えられる。

Abstract

This study is to clear the patterns of grazing behavior of livestock in settlement of Inner Mongolia by fitting GPS data logger on sheep. The grazing behavior of sheep was affected by several impacts, and in this study it was cleared that landform (slope, aspect), distance to water place, fence and pasture area were notable factor to effect grazing behavior. Fence and settlement of nomad were appeared from 1980s in Inner Mongolia. The pasture land was divided into small parts according to the emergence of fence, and associated with settlement of nomads; the same area was used all year by nomads and livestock. It is possible to say the overgrazing in crowded pastures would accelerate the land degradation and desertification.