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Preliminary results on surface and soil characteristics of Brandt's vole (*Microtus brandti*) habitat in Central Mongolia using satellite data

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Abstract: Does Brandt's vole (*Microtus brandti*) makes damage to the environment or provides management? To solve such query, we analyzed land surface characteristics, the nitrogen content and soil hardness measurements at the Brandt's vole colony, for examining changes of land surface and soil by activity of Brandt's vole. The soil hardness was lowest at colony (about 13 mm) and highest at off colony area (about 25 mm). The soil became softer at the colony places. The nitrogen content was high on the mound, and showed high nutritive value of soil. The colonies were located at places with different altitude and slopes, but mostly at no shade (0.73~ 0.87). The soil mixing made by burrowing activity of Brandt's voles might have a great impact on ecosystems of Mongolian steppe. Soft soil on colony enriched in nitrogen presented good condition for such plants as *Artemisia adamsii*. As conclusion, we considered that Brandt's vole might indicate the degradation of pasture and play important role in ecosystem recovery.

Key Words: Brandt's vole, Desertification, Land surface characteristic, Remote sensing, Soil hardness

1. Introduction

Until recently, burrowing rodents had been considered to bring pest damage to the pastureland and the cause of decline of grassland around the world (Zhong *et al*., 1985). The impact of rodents in ecosystem of Mongolia is heavy; herders are considering it as major cause of degradation of pastureland (Zhang and Zhoug, 1981). However, Brandt's vole has habitat to over a wide range in Mongolia, and modifying soil's physical properties through such as increasing above-ground biomass, urinating and defecating. Their roles in ecological diversity are now reconsidered (Yoshihara *et al*., 2010b). This is said to be the "Keystone" species acting as an ecosystem engineer. The Brandt's vole prefers grassland habitat with shorter plants, and easily expanding through pastures that have been heavily grazed by livestock (Zhang *et al*., 2003). According to the researches (Batsaikhan *et al*., 2001) the Brandt's vole dislikes steppes with tall grasses and its expansion is usually in degraded pastures. The colonies of Brandt's vole are significantly changing vegetation, soil and landscape of steppe in Mongolia. However, the influence of the Brandt's vole activity on the soil composition, surface soil temperature and soil moisture at the landscape scale, remained unclear. The goal of the present study is to clarify the effect of Brandt's vole on the grassland by studying the differences in surface characteristics, plant and soil of each landscape. On the basis of these evaluations, we hope to provide good approaches to the management of Brandt's vole in Mongolia.

2. Materials and Methods

2.1. Study site

The study sites (3) are locates 100 km south from Ulaanbaatar in Mongolia. We set a plot with dimensions 100 ×100 m in the site 1 (47°25'54"N, 106°38'26"E) and made a vegetation survey, soil sampling at off colony, new colony and old colony places, simultaneously. We set 2 additional plots (site 2: 47°40'37"N, 106°40'24"E, site 3: 47°35'32"N, 106°38'21"E).

2.2. Satellite data

2.2.1. Normalized Difference Vegetation Index

The Normalized Difference Vegetation Index (NDVI) was calculated using the satellite data from Landsat 5 Themaitic Mapper (TM) (2010/07/31, pixel size 30 m, Path/Row: 131 / 027). NDVI is expressed as follows:

$$NDVI = \frac{NIR - RED}{NIR + RED} \qquad (1)$$

Where, *NIR* is near infrared reflectance and *RED* is visible red light reflectance. This could be calculated from band 3 (*RED*) and 4 (*NIR)* of the Landsat 5 Thematic Mapper (TM).

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Table 1. The calibration constants of Landsat TM sensor.

	Landsat TM
K_1	607.76
K_2	1260.56

2.2.2. Land surface temperature

The Land surface temperature (LST) was calculated using same satellite data. LST is expressed as follows:

$$T = \frac{K_2}{\ln\left(\frac{K_1}{CV_{R2}} + 1\right)} \quad (2)$$

Where, T is degrees Kelvin, CV_{R2} is the atmospherically corrected radiance, and K_1 and K_2 is calibration constants of Landsat TM and the value of K_1 and K_2 are show in **Table 1**.

2.2.3. Landscape characteristic

Landscape characters of the Brandt's vole habitat such as the slope, altitude, aspect, and shaded relief value were studied using ASTER GDEM (pixel size 30m, https://wist.echo.nasa.gov). This data was calculated from geometric corrected ASTER spectral band 3N and 3B.

2.3. Field data

2.3.1. The soil hardness

The measurement was made around each site (3 plots in total), using Yamanakashiki device (Fujiwara Scientific Company). We measured soil hardness at 5 cm, 10 cm and 20 cm depth from the vertical position of soil profile.

2.3.2. Vegetation Survey

At each site 1×1m quadrates were set for the vegetation survey (3 plots). This survey included measurement of the plant height, dry matter amount and coverage for each species found inside the quadrate.

2.3.3. The soil and plant sampling

We measured the nitrogen content and carbon content of soil samples taken at 10 cm depth from surface. The sampling was made three times at each plot (9 samples in 3 plots). We also measured the nitrogen content and carbon content of dominant plant (*Stipa krylovii*). We analyzed carbon and nitrogen content of soil and plant, using N/C analyzer (SUMIGRAPH, NC-22F).

3. Results and Discussion

3.1. The habitat of Brandt's vole

3.1.1. Landscape characteristic

The altitude, slope aspect and shaded relief values in each site was shown in **Table 2**. Colonies of Brandt's vole at all three sites located obviously at un-shaded, bright places. Other landscape characteristics were highly varied.

Table 2. Landscape characteristic of study area.

	Altitude (m)	Slope (°)	Aspect (°)	Shaded relief value
Site 1	1609±10.6	12.30±1.37	85.7±15.6	0.88±0.03
Site 2	1291±4.10	6.43±3.02	308.5±41.6	0.77±0.04
Site 3	1331±0.82	4.76±1.08	67.6±12.6	0.84±0.01

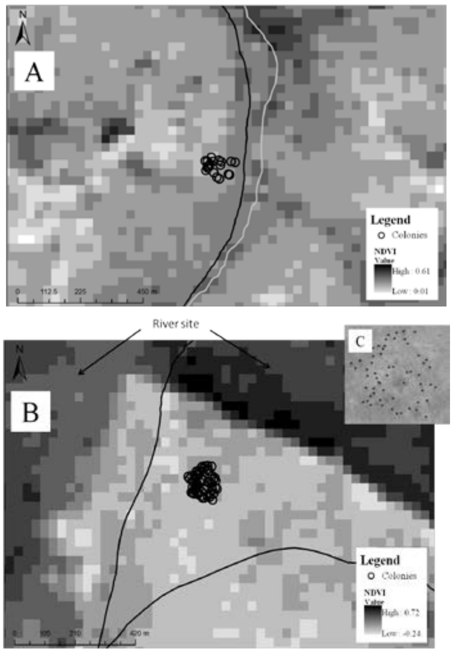

Fig. 1. Normalized Difference Vegetation Index of study area in 31 July 2010. The (A) shows NDVI of study area near site 1; the (B) shows NDVI of study area near site 2; the (C) shows the zoomed image near site 2 to distinguish black circle.

3.1.2. Normalized Difference Vegetation Index

Figure 1 shows the NDVI image calculated from Landsat 5 spectral band 3 and band 4. The NDVI values of colonies in site 1 ranged from 0.23 to 0.28 and mean was 0.25. The NDVI values of colonies in site 2 ranged from 0.15 to 0.19 and mean was 0.17. But, the NDVI values at off colonies in site 1 ranged from 0.20 to 0.34 with a mean 0.27. The NDVI values of off colonies in site 2 ranged from 0.13 to 0.19 and mean was 0.16. The habitat of Brandt's vole appeared to be high in the NDVI from Figure 1, however that values on colony and off colony grounds were unclear at site 1 and 2. Because, in regard to the colony size, a pixel size of satellite image was too large. To make more detailed observation the higher resolution satellite imagery is required.

3.1.3. Land surface temperature (LST)

Figure 2 shows LST calculated from Landsat 5 spectral band 6. The LST values were lowest at the colony of Brandt's vole. LST of colonies in site 1 ranged from 23.4°C to 30.7°C and mean was 31.8°C in site 1. LST of colonies in site 2 ranged from 32.4°C to 32.8°C and mean was 32.7°C. But, the LST of off colonies in site 1 ranged from 29.4°C to 32.8°C and mean was 31.8°C. The LST values in off colonies in site 2 ranged from 31.9°C to 33.2°C and mean was 32.7°C. Because, in regard to the colony size, a pixel size of

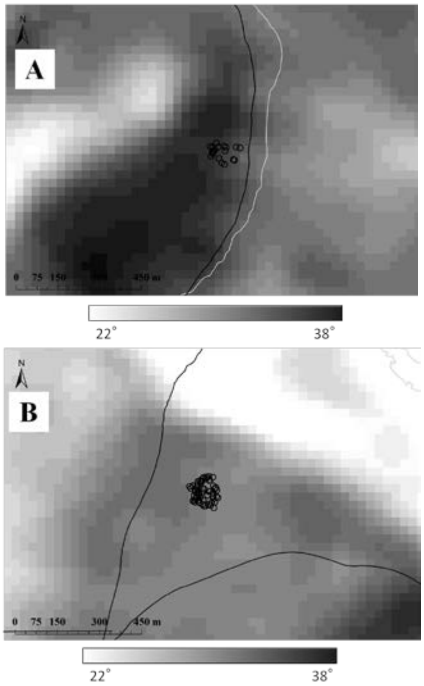

Fig. 2. The LST of study area in 31 July 2010. The (A) shows LST of study area near site 1; the (B) shows LST of study area near site 2; black circle: colony of Brandt's vole.

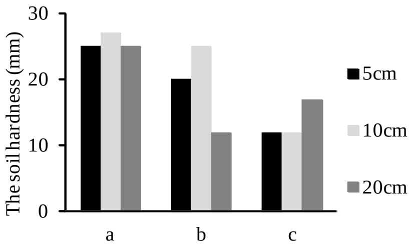

Fig. 3. The soil hardness of each plot in site 1. (a), (b), (c) were the measurement value of off colony; new colony and old colony, respectively.

satellite image was also too large, so we need to use more high resolution satellite imagery to observation LST of habitat of Brandt's vole.

3.2. The effect of Brandt's vole

3.2.1. Soil hardness

The soil hardness was lowest at colony (about 13 mm), highest at off colony area (about 25 mm) (**Fig. 3**). The soil became softer after colony habitation. Thus, we can consider that Brandt's vole digging activity has been softening the soil around its colony ground and that Brandt's vole provided good condition for the plant growth, especially for those species that prefer soft soil.

3.2.2. Vegetation Survey

The plant coverage was low at off colony and new colony (22.9% and 21.5%) and highest at old colony area (69.3%) (**Fig. 4** (A)). Dry matter amount was lowest at off colony (105.2 g/m^2) and highest at old colony area (160.6 g/m^2) (Fig. 4 (B)). Brandt's vole activity supposedly has increased a

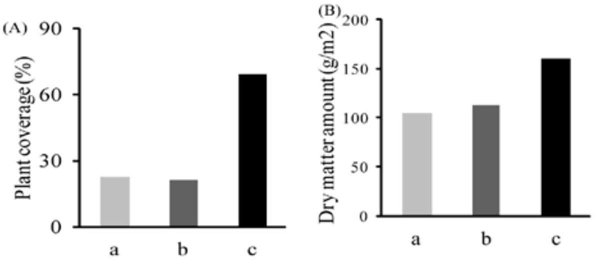

Fig. 4. Plant coverage and Dry matter amount at each plot in site 1. (a), (b), (c) were the measurement value of off colony; new colony and old colony, respectively.

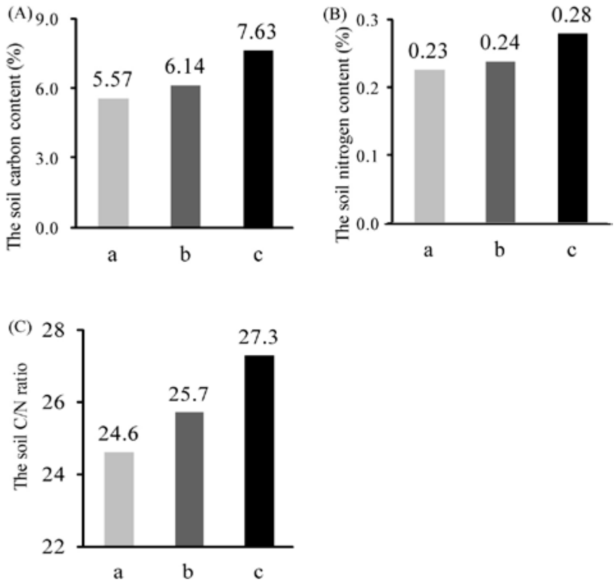

Fig. 5. Carbon and nitrogen content and their ratio of soil in site 1. (a),(b), (c) were the value of off colony, new colony and old colony, respectively.

compartment (*Artemisia adamsii*) on colony ground. Because, livestock don't like to eat *Artemisia adamsi*, and also the colony soil provided better condition for the plant grow.

3.2.3. Comparative studies of carbon and nitrogen of soil and plant in the area of on colony and off colony

The soil carbon content was lowest at off colony (5.57%), highest at old colony (7.63%) (**Fig. 5** (A)). The soil nitrogen content was lowest at off colony (0.23%), highest at old colony (0.28%) (Fig. 5 (B)). The soil C/N ratio was lowest at off colony (24.6), highest at old colony (27.3) (Fig. 5 (C)). Thus, we considered that the increase of both carbon and nitrogen content of soil is due to colonial activity of Brandt's vole. The intake of organic matter to soil can be explained by the large amount of vole's urine and feces.

The carbon and nitrogen content was studied in *Stipa krylovii* (Sk), which is a main dominant species in community and may also serve as an indicator species of healthy undegraded grassland, because in degraded pastures the Sk is mostly eaten by livestock. The carbon content of Sk was lowest at old colony (61.1%) (**Fig. 6** (A)). The nitrogen content of Sk was highest at old colony (2.69%) (Fig. 6 (B)).

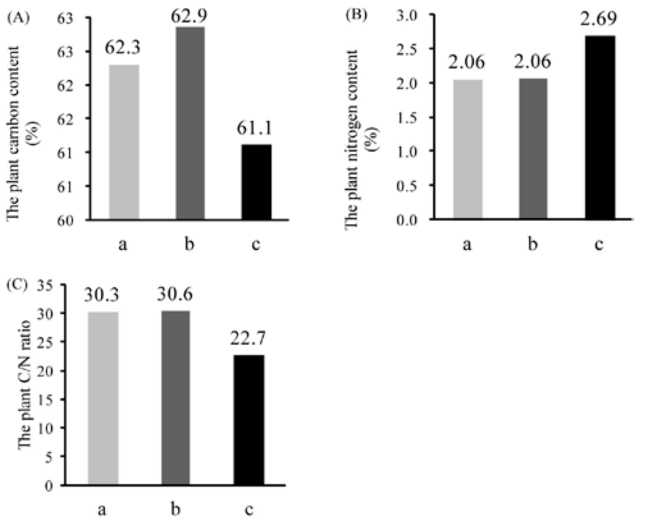

Fig. 6. Carbon and nitrogen content and their ratio of soil in site 1. (a), (b), (c) were the value of off colony, new colony and old colony, respectively.

The C/N ratio of Sk was lowest at old colony (22.7) (Fig. 6 (C)). We suggest that reserves of nitrogen were became much more accumulated at the old colony.

4. Conclusion

Our preliminary research has revealed that Brandt's vole activity softens soil at colony places, increases the nitrogen content of soil, and increased the aboveground biomass amount based on field measurement. However, the satellite imagery that was used in present study did not revealed clear differences between NDVI and LST at colony and off colony places. Because, the pixel size of satellite image was larger than of colony size (5×5 m). The higher resolution for satellite imagery (30×30 m) is needed for thorough observation. Also, more data is required for the detailed analysis and interpretation of the ecosystem role of the Brandt's vole in Mongolia. Thus, it is necessary to evaluate the correlation. So far, the rodent not only consuming the plants in large volumes and harms pastures, but also its activity makes environment more better for various plant species. The Brandt's vole can be rightly called grassland ecosystem manager.

To understand the mechanism, further detailed studies are necessary. We will increase plot numbers to get more data and samples necessary for the thorough future analysis.

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