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Research note

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EFFECT OF BURROWING ACTIVITY OF ROOT VOLE (*MICROTUS OECONOMUS* PALLAS) ON PLANT DIVERSITY IN ALPINE MEADOW

ABSTRACT: Herbivory and burrowing activity of mammals may influence the species composition and diversity of plant communities. The effect of corridors and holes systems constructed by root vole (*Microtus oeconomus* Pallas) on the plant species diversity was studied in the habitat of high - mountain meadow (3250 m a.s.l. in Qinghai-Tibet Plateau, China). By using grid method, these disturbances were studied on 16 plots (100 cm × 100 cm) distributed in 4 transects in studied area, in August 2000 and 2001. The disturbance intensity index, D, was calculated as the percent of the ground surface disturbed by voles in the study area. Plant species were identified and counted on the same plots. In total 46 plant species were identified – 39% of this number was considered as sensitive to the vole disturbances as their occurrence and/or abundance decreased along the disturbance intensity. Generally, a significantly negative correlation ($r = -0.911$, $P < 0.01$) between vole aboveground disturbances and plant species diversity (H') was found. The results suggest that root vole ground disturbances, especially in the form of actively utilized holes and corridors have significantly negative influence on plant species diversity in high-mountain grassland habitat.

KEY WORDS: burrowing, ground disturbance, root vole (*Microtus oeconomus*), species diversity, alpine meadow

Disturbances by herbivorous rodents can alter plant biomass and productivity (Zhang and Liu 2003, Kraft *et al.* 2004), plant species richness and diversity (Michael and Guy 2000, Zhang and Liu 2003) in grassland and forest ecosystems. Herbivorous rodents affect plant communities directly and indirectly. Direct disturbances include herbivory, burrowing, and mound building. Another ones result from alteration of microclimates of ungrazed plant species (McNaughton 1992) or modification of plant communities by deposition of nitrogen and other compounds Nauertz *et al.* 2004).

The root vole or tundra vole (*Microtus oeconomus*, Pallas, 1776) is a species of small mammal that occurs commonly in wet grasslands of both Arctic and temperate biomes. It is also the small mammal species widespread in alpine meadow area in Qinghai-Tibet Plateau. It inhabits the sites with greater coverage and dense plant layer (Sun *et al.* 2004). It belongs to sub-aerial mouse. The effect of root vole burrowing activities on the vegetation community is poorly known. The objective of this study was to know whether the burrowing disturbances, such as corridors and holes made by voles, significantly influence the

plant species diversity in alpine grassland ecosystem.

This study was conducted at the Haibei Alpine Meadow Ecosystem Research Station (HAMERS), the Chinese Academy of Sciences, which is located in the northeast of Qinghai-Tibet Plateau (37°29' – 37°45'N, 101°12' – 101°23'E), on average altitude 2900 – 3500 m a. s. l. of the valley areas. The landscape is characterized by large mountain ranges with steep valleys and gorges interspersed with relatively plain and wide grassland areas. The climate at HAMERS is dominated by the southeast monsoon type, with severe and long winters and short cool summers. The average air temperature is -1.7°C with extremes of 27.6°C (maximum) and -37.1°C (minimum). During winter months, the average temperature can drop to -15°C or even -20°C in highland areas; while during summer, the temperature in the warmest month (July) averages $14 \sim 22^{\circ}\text{C}$ in the valleys and $4 \sim 10^{\circ}\text{C}$ in the mountains. The average annual precipitation ranges from 426 to 860 mm, 80% of which falls in the short summer growing season from May to September. The annual average sunlight is 2462.7 hrs with 60% of total available sunshine (Zhao and Zhou 1999, Sun *et al.* 2005).

Kobresia humilis is the dominant species in this alpine meadow vegetation, together with various accompanying species, such as *Festuca rubra*, *F. ovina*, *Poa* spp., *Saussurea superba* Anth and *Gentiana straminea* Maxim (Zhao and Zhou 1999).

The burrowing disturbances and plant diversity data were collected (in August 2000 and 2001) using four 50-m long transects located in 4 ha meadow area. In each transect, 4 sample plots (100 cm \times 100 cm) were selected with 10-m intervals along transect. In each plot, disturbance variables were recorded using 100 smaller grid systems. The disturbances included the corridors and holes (both "active" and "non-active" holes) of voles. Each grid was inspected whether there was a corridor and/or a hole and the number of grids with corridors and holes found in all the 100 grids of each plot was assessed. The disturbance intensity was denoted as:

$$D \% = \frac{\sum (\text{number of corridors} + \text{holes})}{100 \text{ grids}} \quad (1)$$

i.e. the disturbance intensity was taken as the number of corridors and holes per 100 small grids i.e. per 1m^2 . In this way, D % could be considered as the percent of the ground surface disturbed by voles in study area.

To verify which hole is actively used, the following method was applied. The balls of cotton wool were inserted into the hole in the morning. After the peak of vole activity (08:00 ~ 11:30 and 15:30 ~ 19:00 in summer; 10:45 ~ 16:00 during winter), the presence of cotton wool was checked.

Plant species components were assessed simultaneously at the same plots as the disturbance intensity. All plant species were recorded in each sample plot. Species diversity,

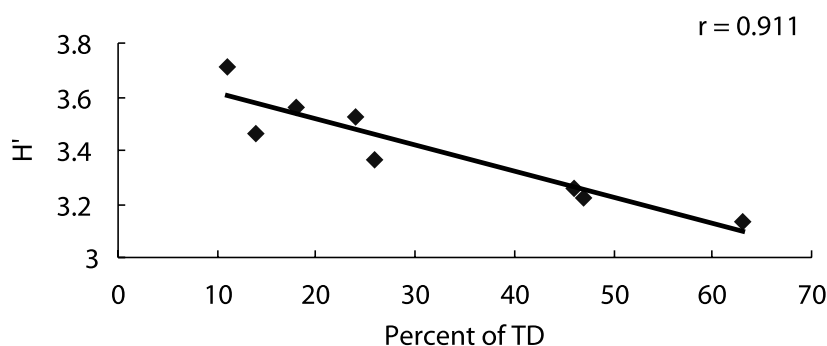


Fig. 1. The correlation between ground disturbances made by root vole (*Microtus aeconomus*) and plant diversity (i.e. Shannon – Wiener index H') of alpine meadow vegetation. TD – total disturbance i.e. the percent of the area disturbed by holes and corridors made by voles. Each point represents the value for one plot.

H' (Shannon – Wiener index, Krebs 1999) was calculated for each plot using number of species and the number of their individuals. Most plots had only 1 (occasionally 2) individual (s) of single species of plant, even though >1 species of plant was usually found (Michael and Guy 2000).

SPSS system for Windows was employed for statistics analysis. Pearson correlation (two-tailed) was employed for analyzing the correlation between root vole disturbances (including “active” holes, “non-active” holes, and corridors) and species diversity (Zhang and Wang 2001).

A strong negative correlation ($r = -0.911$, $P < 0.01$) was found between the intensity of

root vole disturbances and plant species diversity, and the correlation was significant at the 0.01 level (2-tailed) (Fig.1). The corridors dominated in the ground disturbances made by voles (up to 80 % of all disturbed plots) and it is why the correlation between the percent area disturbed by corridors and plant species diversity was also significantly negative ($r = -0.887$, $P < 0.01$).

It was also found that 39% of the total list of meadow plants found in the area is sensitive to the burrowing activity of voles as their occurrence and/or abundance decreased in the plots disturbed (Table 1).

The result of this study indicated that the response of plant community to the ground

Table 1. The plant species response to root vole (*Microtus oeconomus*) disturbances of the above ground layer of alpine meadow. Sensitive – means decreasing in relation to vole activities.

Species	Sensitive	Insensitive
<i>Artemisia roxburghiana</i> Bess.(not italics)	*	
<i>Lonicera tangutica</i> Maxim.	*	
<i>Saussurea arenaria</i> Maxim.		*
<i>Ajania flaccidus</i> Bunge.		*
<i>A. tenuifolia</i> (Jacq.) Tzvel.		*
<i>Gueldenstaedtia diversifolia</i> Maxim.		*
<i>Polygonum sibiricum</i> Laxm.		*
<i>Potentilla anserine</i> L.		*
<i>P. nivea</i> L.		*
<i>P. anserine</i> L.		*
<i>Notopterygium forbesii</i> Boiss.		*
<i>Lancea tibetica</i> Hook. f. et Thoms.		*
<i>Anaphalis lactea</i> Maxim.		*
<i>Leontopodium nanum</i> Hook. f. et Thoms.	*	
<i>Aconitum gymmandrum</i> Maxim.	*	
<i>Delphinium caeruleum</i> Jacq.	*	
<i>Thalictrum alpinum</i> L. var. <i>elatum</i> Ulbr.		*
<i>T. alpinum</i> L.		*
<i>Ranunculus membranaceus</i> Royle.		*
<i>Gentiana farreri</i> Balf. f.		*
<i>G. aristata</i> Maxim.		*
<i>G. straminea</i> Maxim.	*	
<i>Stellaria umbellata</i> Turcz.		*
<i>Carex atrofusca</i> Schkuhr subsp.		*
<i>Kobresia humilis</i> Serg.		*
<i>Elymus nutans</i> Griseb.		*

Species	Sensitive	Insensitive
<i>Festuca ovina</i> L.		*
<i>Stipa aliena</i> Keng.		*
<i>Poa</i> spp.		*
<i>Trigonella ruthenica</i> L.		*
<i>Glaux maritima</i> L.		*
<i>Viola kunawarensis</i> Royle Illustr.	*	
<i>Taraxacum leucanthum</i> Ledeb.		*
<i>Parnassia trinervis</i> Drude.	*	
<i>Oxytropis ochrocephala</i> Bunge.	*	
<i>O. kansuensis</i> Bge.	*	
<i>Koeleria cristata</i> (L.) Pers.		*
<i>Festuca rubra</i> L.		*
<i>Astragalus adasurgens</i> Pall.	*	
<i>Scirpus distigmaticus</i> (Kuk.) Tang et Wang	*	
<i>Gentianopsis paludosa</i> (Munro.) Ma	*	
<i>Pedicularis kansuensis</i> Maxim.	*	
<i>P. lyrata</i> Prain.	*	
<i>Iris tectorum</i> Maxim.	*	
<i>Elsholtzia calycocarpa</i> Diels.	*	
<i>Euphrasia tatarica</i> Fisch.	*	
No. of species	46	28

disturbances made by voles could be very profound. 39% of the plant species composition of this unique habitat, mostly the herbaceous plants, appeared to be sensitive to burrowing activities of the voles. The result is that the overall plant taxonomic diversity is strongly inversely related to the intensity of burrowing disturbances of the aboveground layer of vegetation.

The food preference of voles is likely the main reason for that. The leaves and buds of herbs (Table 1), especially adjacent to the vole corridors were the main food of voles (Zhou *et al.* 1996). We found that the vole feces are distributed mainly along the corridors (Sun *et al.* 2004). The eaten leaves and buds will decrease plant total leaf area, increase plant mortality, and decrease the plant reproduction.

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