

Fluctuations and patterns of desert rodent communities under human disturbance: fluctuating tendency and sensitive response of their population

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Abstract The four kinds of sites under different kinds of human disturbances, i.e. a farmland area, a rotational-grazing area, an over-grazing area and a prohibited-grazing area, were selected in the typical region of the Alashan Desert of Inner Mongolia from April to October in 2002, 2003 and 2004 respectively. The fluctuating tendency of rodent communities and the sensitive response of their populations were studied using mark-recapture and trap-day methods. The four kinds of mark-recapture samples and line samples were taken in different human disturbance areas. The area of the mark-recapturing sample was 0.95 hm² and that of the line sample was 10 km². The samples were collected every month in the mark-recapturing sites for four consecutive days and in line sites in April, July and October every year. The variable matrix was composed of the numbers of captured rodents of the rodent communities. The sensitive response of the populations in the communities was analyzed with principal component analysis (PCA). Results showed that there were different types of rodent communities under different kinds of human disturbance on two scales in three years. In each scale, there were large differences in both the number of species and the number of main population in the rodent communities under different kinds of human disturbance on the farmland area and over-grazing area especially. The results of PCA showed that the sensitive response of the populations of the communities was significantly different under different kinds of human disturbance on the two scales in the three years. *Cricetulus barabensis* was the most sensitive on the farmland area, there were no differences in sensitive response of the various rodents on the rotational-grazing area, and *Dipus sagitta* and *Phodopus roborovskii* were the most sensitive in the over-grazing area.

Keywords rodent, community, human disturbance, population, sensitive, desert

1 Introduction

Because the landscape predominated by mankind was more widespread, mankind's activity caused the habitat fragmentation, the patch of natural habitat became a permanent structure characteristic of landscape (Forman et al., 1986). It becomes more and more important to understand the habitat fragmentation of the biotic communities and population in order to protect and manage the biotic fauna (Holling, 1992). The discussion focused on the species that were sensitive to fragmentation and fragmentation result of the structure and the function for natural communities, and usually concerned the result of patch of natural habitat fragmentation caused by mankind. Many researches focused on the relationship between the area of patch of natural habitat (or islands) and the quantity of living creature (MacArthur and Wilson, 1967; Rosenzweig, 1995; Barbara et al., 1998; McCarthy and Lindenmayer, 1999; David et al., 2000; Fox and Fox, 2000). Nowadays, the new theories concentrated in great quantities of researches of rodent communities, which concern pattern, process and scale in the ecology and habitat fragmentation (Steen et al., 1996; Antonio et al., 2000; Mark and David, 2000; James et al., 2001; Matthew and Norman, 2001; Steephen et al., 2002). It imported important theories and practice meaning for understanding the structure and function of ecosystem, studying dynamic characteristic of the rodent community's pattern under different disturbance. However, studying rodent community's patterns in the weak ecosystem of the desert region under different disturbance has a great significance for the development of the restoration ecological theories and the managing ecosystem in the process of the Western Region Development of China. The study on the dynamic varieties of rodent community patterns was almost a

blank in the desert region under different disturbance in China and the world. The fluctuation trend of the rodent community's pattern under different disturbance was studied from 2002 to 2004 in the typical desert region of Alashan in Inner Mongolia. The results were as follows.

2 Natural conditions

The studied position (104°10'–105°30'E, 37°24'–38°25'N), the natural desert landscape, is located in south of Alashan in Inner Mongolian of China and in the east of the Tenggeli desert where vegetation was sparse. Its structure was monotonous. The degree of vegetation coverage was low only from 1% to 20% generally. The plant species was needy, chiefly including shrub, half-shrub, small shrub and half small shrub of the drought living, the super drought living and the salt living. The good perennial grass of *Gramineae* and *Leguminosae* were less. The colonization plants belonged to *Chenopodiaceae*, *Compositae* and *Zygophyllaceae* as principal, second belonged to *Rosaceae* and *Tamaricaceae*. Its topography was raised and fallen with mound, sand dune and even pool alternately. Its weather was a typical plateau continental climate. It was chill and aridity in winter, extreme hot in summer. The difference of temperature was significant between day and night. The extreme lowest temperature was –36°C, and the highest 42°C. Average annual air temperature was 8.3°C. The frost-free period was 156 days. The annual precipitation was from 45 to 215 mm, and very asymmetry, concentrated in July to August chiefly. The annual evaporation was from 3000 to 4700 mm. The soil was brown desert soil with weak eluviations, which was lax and barren. The content of top soil organic was from 1% to 1.5% with a lot of dissolubility salt.

According to dissimilarity of utilized grassland in the region, the four kinds of habitats under different disturbances were chosen in which the studied sites were conducted as follows.

(1) **Farmland area:** this area had been farmed for seven years. The vegetation primarily regarded the artificial planted half-shrub, small shrub of *Haloxylon ammodendrom*, *Calligomum mongolicum* and the perennial grass of *Hedysarum scoparium*, *Medicago sativa* etc. as principal, with the annual weed of *Nanophyton erinaceum*, *Bassia dasyphrium* etc. as companions. The degree of vegetation coverage could reach 65%. The soil was sandy; its humidity content was from 2.77% to 10.58%.

(2) **Rotational-grazing area:** covering an area of 60 hm², this area was divided into four small areas for rotational-grazing with 100 sheep. Each small area was utilized once monthly. The main constructive species was *Zygophyllum pterocarpum*, with *Reaumures soongorica*, *Oxytropis acipphlla* etc. of perennial small shrub and *Peqanum nigellastrum*, *Bassia dasyphylla* of the annual weed as companions. The degree of vegetation coverage reached 24.5%. The soil was sandy; its humidity content was from 2.46% to 9.32%.

(3) **Over-grazing area:** this area was utilized for over-grazing and excessiveness without a break. The main constructive species was *Nitraria* spp and *Zygophyllum pterocarpum*, with the *Reaumures soongorica*, *Oxytropis acipphlla* and *Cleistogenes squarosa* etc. of perennial plant and *Suaeda glauca*, *Plantago lessingii* etc. of annual plant were as companions. The degree of vegetation coverage was lower than 8.5%. The soil surface turns severely into sand, and its humidity content was from 4.66% to 12.46%.

(4) **Prohibited-grazing area:** this area was prohibited grazing more than five years. The main constructive species was *Reaumures soongorica* and *Salsola passerine*, and the second was *Zygophyllum pterocarpum*, *Ceratoides latens*, *Caragana stenophylla* and *Artemisia ordosica* etc. of small shrub. The dominant species of herbage was *Pennisetum flaecidum*, with *Cleistogenes squarosa*, *Bassia dasyphrium* etc., as companions. The degree of vegetation coverage was higher than 29.5%. The soil was sandy; its humidity content was from 4.40% to 8.22%.

3 Methods

The four kinds of habitats under different disturbances, farmland, rotational-grazing, October in 2002, 2003 and 2004. The fluctuation trend of the rodent communities' patterns and the sensitivity res prohibited-grazing, over-grazing areas, were chosen for studied sites in typical desert region of Alashan from April to pond of the dominant populations were studied. The marking banishes areas were designed in each disturbance type for 0.96 hm² with the mark-recapture method. The iron wire-cages were away 15 m and the distance between lines was 15 m. The rodents were captured continuously for four days every month. For assurance without influence of mark-recapturing and trapping each other in the meantime, other four lines were chosen under four kinds of different disturbances to sample (the area of each line was about 10 km²), with the trap-day method, and four sites were conducted in each line. The area of each site was 10 hm² where 500 trap-days were conducted. Totally 2000 trap-days were conducted in each line. The sampled time was in April, July and October every year. The variables matrixes were constituted by numbers ratio of rodents captured to compare and analyze the rat species in the pattern of rodent communities in farmland, rotational-grazing, over-grazing and prohibited-grazing areas (The prohibited-grazing area conducted and acted check against, keeping environment condition originally). The constitute rats of the rodent communities were ordered by principal component analysis (PCA) method with the variables matrixes under different disturbances, respectively. It was established as the biggest function, the contribute rate of which was the biggest under the disturbance, and who was the most sensitive to the disturbance. Based on above, sensitivity respond of main populations of rodent communities was analyzed under the different disturbances.

4 Results

4.1 Changing trend of the rodent communities' pattern under different disturbance

The changing trend of the rodent community's pattern under the different disturbance condition in line sites from 2002 to 2004 was analyzed (shown in Tables 1 and 2). In the meantime, the variety characteristic of which in the mark sites was analyzed, and the results were shown in Table 3.

It can be seen from Table 1 that under different disturbance in the larger scale (line sites), the rodent communities patterns were obviously different. The species of each community expresses a consistent characteristic for three years, the prohibited-grazing area has five to six kinds of species, minimally. However, the number of constitute species all increased in corresponding patches disturbed (Other three spot pieces). The number of constitute species in over-grazing was from eight to eleven, which is the most, from seven to nine in rotational-grazing area, and from seven to eight in farmland area. Analyzing the species and the quantity of constitute species of communities, the difference of communities from each other was very significant: the most outstanding characteristic in farmland area was appearing of *Meriones unguiculatus*, which completely oriented the farmland and semi-desert habitats. The quantity of *Meriones meridianus* is the most, and its ratios of numbers captured shared 47.8% in 2002, 45.1% in 2003 and 67.8% in 2004. At the same time, *Dipus sagitta* completely disappear; the over-grazing turns to sand seriously. Quantity of *Dipus sagitta* and *Phodopus roborovskii* increased, and their ratios of numbers captured shared 71.1% in 2002, 65.2% in 2003 and 67.8% in 2004; quantity of *Meriones meridianus* and *Phodopus roborovskii* in rotational-grazing area was high, their ratios of numbers captured shared 40.7% in 2002, 85.1% in 2003 and 81.4% in 2004, showing that the habitat in this disturbance type has already turned to sand seriously; the outstanding characteristic in prohibited-grazing area was that quantity of *Meriones meridianus* and *Cricetulus barabensis* gained dominantly, and the quantity presents up-trend in these three years. Their ratios of numbers captured shared 66.5% in 2002, 79.7% in 2003 and 93.8% in 2004.

The seasonal number change of each area community's components under different disturbance conditions can be seen from Table 2. The seasonal changes performance of the rodent communities under four kinds of different disturbance conditions in three years were as follows: in farmland area in different months of three years, opposite ratio of the rodent communities components was higher. Total number of rodent captured in four areas shared 21.51% (April), 26.71% (July) and 32.66% (October), respectively, in 2002; 46.25% (April), 20.17% (July) and 32.88% (October), respectively, in 2003; 37.17% (April), 25.24% (July) and 18.45% (October), respectively, in 2004. The seasonal change of component number was more obvious in rotational-grazing and over-grazing areas. In rotational-grazing area, the quantity was higher

(27.62%) in April 2002, but which descended very quickly in July (10.50%). Although the quantity got instauration in October (19.84%), it was not the same as that in April. The quantity increased nearly one times from April to July in 2003, descended 50% on October, appeared the most high peak on July in 2004; in over-grazing area, it increased nearly one times from April (24.42%) to July (39.04%) in 2002, but descended to component numbers of April (25.54%) in October; in 2003, component number increased from 12.55% in April to 20.65% in July, which increased nearly one times, but in October, which descended near to that in April (14.29%). Therefore, the component number changed significantly by season, appeared the most high peak in July 2004; the features of prohibited-grazing area was that there was little change in every season (April, July, October) in three years, and it is more stable from 23.91% to 27.80% in three years.

From the quantity change of component species of rodent communities under different disturbance (Tables 1–3), the consistent characteristic in three years was that the number of *Cricetulus barabensis* had always been in up-trend from April to October in prohibited-grazing area and farmland area, but been changed scarcely in every month in over-grazing and rotational-grazing areas; the component numbers of *Dipus sagitta* and *Phodopus roborovskii* was always higher from April to October in three years, that of *Dipus sagitta* in over-grazing area and rotational-grazing area shared 47.37% and 76.19% (April), 32.6% and 45.61% (July), 42.47% and 52.13% (October) in 2002; 15.45% and 70.15% (April), 6.63% and 20.93% (July), 6.25% and 11.76% (October) in 2003; 8.15% and 42.25% (April), 11.73% and 33.53% (July), 22.55% and 50.76% (October) in 2003. That of *Phodopus roborovskii* in over-grazing area and rotational-grazing area shared 28.42% and 9.52% (April), 6.52% and 19.30% (July), 15.07% and 17.02% (October) in 2002; 19.09% and 16.42% (April), 73.12% and 42.32% (July), 35.42% and 39.71% (October) in 2003; 44.85% and 15.41% (April), 52.735 and 28.13% (July), 25.75% and 1.76% (October) in 2004.

It was seen from Table 3 that in the small scale (marking sites 0.96 hm²), the component species of communities under different disturbance in three years had been almost consistent, which was all six kinds of species in rotational-grazing, over-grazing and prohibited-grazing areas, which was five or six kinds of species in farmland area, but the number difference of component species of communities was very significant. One obvious differentiation was that habitat had been fragmented completely in farmland area, caused structure of component species of communities taken place materiality variety that *Cricetulus barabensis* adapted to farmland increased obviously from 2002 to 2003, but descended significantly in 2004, shared 30.19% of total species number captured in 2002, that was higher in 2003, reached 50%, but that was 6.71% in 2004. The *Dipus sagitta* that adapted to sand and desert disappeared completely. Another characteristic was that primary phytocoenosis already turned to sand severely under condition of over-grazing in over-grazing area, so the *Dipus sagitta* that adapted to sand increased

Table 1 Features of rodent communities pattern changed under different disturbance in line sites

Year	Disturbance types	2002				2003				2004						
		Prohibited-grazing area	Over-grazing area	Rotational-grazing area	Farmland area	Σ	Prohibited-grazing area	Over-grazing area	Rotational-grazing area	Farmland area	Σ	Prohibited-grazing area	Over-grazing area	Rotational-grazing area	Farmland area	Σ
	<i>Citellus dauricus</i>	0	0.014	0.023	0.003	0.010	0	0.014	0.026	0.008	0.012	0	0.016	0.032	0.003	0.012
	<i>Allactaga sibirica</i>	0.186	0.109	0.075	0.080	0.113	0.079	0.040	0.011	0.047	0.044	0.043	0.031	0.014	0.083	0.044
	<i>Dipus sagitta</i>	0.047	0.547	0.425	0	0.257	0.006	0.285	0.084	0	0.073	0.009	0.388	0.123	0	0.118
	<i>Cardiocranius paradoxus</i>	0	0.003	0	0	0.003	0	0	0	0	0	0	0	0	0	0
	<i>Salpingotus kozlovi</i>	0.007	0.012	0	0	0.005	0	0.003	0	0	0.001	0	0.023	0	0	0.005
	<i>Salpingotus crassicauda</i>	0	0.009	0	0	0.003	0	0	0	0	0	0	0	0	0	0
	<i>Meriones meridianus</i>	0.320	0.057	0.168	0.478	0.255	0.430	0.254	0.260	0.451	0.361	0.455	0.229	0.330	0.678	0.432
	<i>Meriones unguiculatus</i>	0	0	0.009	0.035	0.011	0	0	0.004	0.054	0.018	0	0.004	0	0.023	0.007
	<i>Cricetulus barabensis</i>	0.346	0.034	0.047	0.369	0.200	0.367	0.029	0.026	0.388	0.224	0.483	0.016	0.004	0.179	0.185
	<i>Cricetulus evermanni</i>	0	0.034	0.009	0.006	0.014	0.006	0.009	0	0.005	0.004	0.009	0.004	0.014	0.007	0.009
	<i>Phodopus roborovskii</i>	0.095	0.163	0.238	0.022	0.123	0.112	0.368	0.591	0.037	0.261	0	0.291	0.484	0.027	0.189
	<i>Mus musculus</i>	0	0.023	0.005	0.006	0.010	0	0	0	0.011	0.003	0	0	0	0	0
	Σ	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Numbers of species	6	11	9	8	12	6	8	7	8	10	5	9	7	7	9

Note: the data are ratios of numbers of captured rodent in above table.

Table 2 Features of component numbers seasonal changed of rodent communities under different disturbance

Year	Month	2002				2003				2004			
		April	July	October	Σ	April	July	October	Σ	April	July	October	Σ
	Farmland area	0.215 1	0.267 1	0.328 8	0.271 3	0.462 5	0.201 7	0.395 0	0.314 5	0.371 7	0.252 4	0.184 5	0.257 5
	Rotational-grazing area	0.276 2	0.105 0	0.198 4	0.186 1	0.206 0	0.376 6	0.100 8	0.268 2	0.216 8	0.323 3	0.100 3	0.243 8
	Over-grazing area	0.244 2	0.390 4	0.255 4	0.303 5	0.125 5	0.206 5	0.142 9	0.170 6	0.115 0	0.263 4	0.210 4	0.220 7
	Prohibited-grazing area	0.264 5	0.237 4	0.217 4	0.239 1	0.206 0	0.215 2	0.361 3	0.246 7	0.296 5	0.160 9	0.504 9	0.278 0
	Σ	1.000 0	1.000 0	1.000 0	1.000 0	1.000 0	1.000 0	1.000 0	1.000 0	1.000 0	1.000 0	1.000 0	1.000 0

Note: the data in the table are ratios of numbers of rodent captured.

Table 3 Features of component species changed of rodent communities under different disturbance in marking sites

Year		<i>Allactaga sibirica</i>	<i>Dipus sagitta</i>	<i>Citellus dauricus</i>	<i>Phodopus roborovskii</i>	<i>Meriones meridianus</i>	<i>Cricetulus barabensis</i>	<i>Cricetulus eversmanni</i>	<i>Meriones unguiculatus</i>	Σ	numbers of species
2002	Prohibited-grazing area	0.094	0.132	0.038	0.415	0.264	0.057	0	0	1	6
	Over-grazing area	0.216	0.353	0.020	0.196	0.157	0.059	0	0	1	6
	Rotational-grazing area	0.116	0.101	0.029	0.101	0.638	0	0.015	0	1	6
	Farmland area	0.057	0	0.094	0.113	0.434	0.302	0	0	1	5
	Σ	0.121	0.144	0.045	0.202	0.399	0.099	0.005	0	1	7
2003	Prohibited-grazing area	0.116	0.036	0.063	0.071	0.616	0.098	0	0	1	6
	Over-grazing area	0.047	0.103	0.094	0.131	0.598	0.028	0	0	1	6
	Rotational-grazing area	0.087	0.039	0.039	0.231	0.567	0.019	0.019	0	1	7
	Farmland area	0.010	0	0.010	0.031	0.265	0.561	0	0.122	1	6
	Σ	0.067	0.045	0.052	0.116	0.518	0.169	0.005	0.029	1	8
2004	Prohibited-grazing area	0.113	0.024	0.036	0.191	0.566	0.071	0	0	1	6
	Over-grazing area	0.110	0.238	0.043	0.055	0.524	0.031	0	0	1	6
	Rotational-grazing area	0.032	0.011	0.021	0.149	0.723	0.064	0	0	1	6
	Farmland area	0.208	0	0.017	0.033	0.625	0.067	0	0.050	1	6
	Σ	0.119	0.081	0.031	0.108	0.593	0.057	0	0.011	1	7

Note: the data are ratios of numbers of captured rodent above table.

largely, its number shared 35.29% of total numbers captured in 2002, 10.32% in 2003 and 23.76% in 2004. The number of *Meriones meridianus* increased in rotational-grazing area shared 63.77% of total number in 2002, 56.72% in 2003 and 72.32% in 2004.

In the small scale (marking sites 0.96 hm²), the number captured of all species presented up-trend year by year. In the large scale scope (line sites, 40 hm²), the common characteristic was that the number of every species was on peak in 2003, but was obviously low in 2002 and 2004. Therefore, from the number of rodent and patterns of rodent communities analyzed above, the differences of different studied scales could be seen in preliminary.

4.2 Sensitivity analysis of the dominant population of rodent communities under different disturbances

In order to thoroughly study the change of community's patterns of the desert rodent under different disturbances and the dominant population's reaction characteristics of rodent communities to different disturbance types, the captured ratio and the biomass ratio of the community's composed species were contained in the variable matrixes, using principal component analysis method to analyze matrixes on two different scales (the marking sites, area: 0.96 hm²; the line sites, area: 40 hm²) in three years, respectively. The results were shown in Tables 4 and 5 (the marking sites) and Tables 6 and 7 (the line sites).

The order process was arranging the sites or species in certain space, and making that the variable matrix can reflect the certain ecological gradient, so it can explain the relationship between the distribution of the community or the species and the environment (Liang et al., 2004). Authors used the PCA method to order the composed species of every rodent community which was under different disturbance conditions, meaning used the reduction dimension analysis to find the principal component's maximum cumulative percentage

Table 4 Principal component cumulative percentage in marking sites

Year	Principal component	Farmland area	Rotational-grazing area	Over-grazing area	Prohibited-grazing area
2002	1	0.403 7	0.467 5	0.594 1	0.388 7
	2	0.721 9	0.727 9	0.800 5	0.708 2
	3	0.881 5	0.906 5		0.919 6
2003	1	0.423 5	0.470 8	0.475 3	0.443 6
	2	0.768 8	0.689 4	0.852 6	0.732 8
	3	0.941 1	0.860 6		0.921 8
2004	1	0.511 2	0.430 1	0.550 0	0.505 0
	2	0.690 4	0.636 9	0.822 9	0.750 5
	3	0.856 0	0.820 5		0.953 0

of the species on the first three-dimension (the cumulative percentage has reached 75%, which was meaning that the amount of information of the first three-dimensional order represented more than 75% information of the overall ranking) among the multidimensional spatial information. These species played the significant role in the first three-dimensional order, and they were the dominant population in the community, which also noted that these species had close relationship with their community environment (the different disturbance conditions) compared with other species, thus these species were inducted to be the most sensitive populations to the different disturbance conditions.

It can be concluded from Table 4 that in the small scale (the marking sites, 0.96 hm²), the results of the PCA analysis showed that the cumulative percentage of four different disturbance regions in 2002 reached 0.8815 (the farmland area), 0.9065 (the rotational-grazing area), 0.8005 (the over-grazing area, and the first two-dimension) and 0.9196 (the prohibited-grazing area), respectively; in 2003, reached 0.9196 (the farmland area), 0.8606 (the rotational-grazing area), 0.8526 (the over-grazing area, and the former two-dimension) and 0.9218 (the prohibited-grazing area), respectively; in 2004, reached 0.8560 (the farmland area), 0.8205 (the rotational-grazing area), 0.8229 (the over-grazing area,

Table 5 Eigenvectors on the first three principal component of rodent communities under different disturbance in marking sites

Year		Farmland area			Rotational-grazing area			Over-grazing area		Prohibited-grazing area		
		Prin1	Prin2	Prin3	Prin1	Prin2	Prin3	Prin1	Prin2	Prin1	Prin2	Prin3
2002	X1	0.268 3	0.345 4	0.261 0	0.311 8	0.288 3	0.232 9	-0.279 8	-0.381 9	0.352 2	0.291 6	-0.012 6
	X2	0.258 7	0.327 4	0.258 2	0.319 6	0.269 6	0.228 0	-0.301 0	-0.360 0	0.353 4	0.271 1	0.092 4
	X3	0.000 0	0.000 0	0.000 0	-0.300 4	0.085 7	0.329 0	0.284 1	0.335 7	-0.056 4	0.151 8	0.563 0
	X4	0.000 0	0.000 0	0.000 0	-0.317 5	0.074 8	0.345 6	0.328 9	0.255 5	-0.039 8	0.082 7	0.603 6
	X5	0.442 5	-0.177 3	-0.250 3	-0.164 6	-0.227 6	0.533 5	-0.278 5	0.350 2	-0.360 4	0.288 7	-0.154 3
	X6	0.415 8	-0.104 3	-0.382 1	-0.168 0	-0.242 7	0.496 7	-0.243 7	0.453 7	-0.376 0	0.266 0	-0.109 3
	X7	-0.488 7	0.075 8	-0.041 9	0.000 0	0.000 0	0.000 0	0.333 8	-0.073 6	-0.031 8	-0.477 2	-0.119 3
	X8	-0.487 6	0.076 0	-0.073 6	0.000 0	0.000 0	0.000 0	0.309 9	-0.105 8	-0.023 7	-0.474 4	-0.134 9
	X9	0.104 1	0.441 9	0.211 4	0.400 5	-0.108 7	0.152 0	0.303 0	-0.313 7	0.364 6	-0.154 2	0.208 0
	X10	0.024 6	0.435 2	0.207 2	0.399 4	-0.123 0	0.155 3	0.323 4	-0.272 6	0.290 3	-0.322 0	0.183 6
	X11	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0
	X12	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0
	X13	0.000 0	0.000 0	0.000 0	0.111 9	0.480 8	0.177 3	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0
	X14	0.000 0	0.000 0	0.000 0	0.111 9	0.480 8	0.177 2	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0
	X15	0.046 6	-0.409 3	0.530 0	0.331 7	-0.331 5	0.108 8	0.225 1	0.120 1	0.350 5	0.197 1	-0.296 3
	X16	0.046 6	-0.409 3	0.530 0	0.315 1	-0.348 4	0.113 2	0.225 1	0.120 1	0.365 3	0.196 0	-0.277 6
2003	X1	0.275 2	0.380 0		-0.143 2	0.257 0	-0.493 0	0.321 3	-0.167 7	-0.039 7	-0.470 5	-0.188 9
	X2	0.275 2	0.380 0		-0.131 1	0.277 7	-0.508 3	0.317 8	-0.175 2	-0.075 5	-0.509 3	-0.113 0
	X3	0.000 0	0.000 0		-0.259 2	0.191 6	0.263 2	0.391 6	-0.133 0	-0.157 3	0.203 2	0.523 9
	X4	0.000 0	0.000 0		-0.232 1	0.194 2	0.300 2	0.370 0	-0.128 0	-0.136 1	0.233 1	0.521 6
	X5	0.419 3	-0.110 5		-0.355 8	-0.125 5	0.150 2	-0.344 6	-0.253 0	-0.419 0	0.030 2	-0.015 6
	X6	0.159 8	-0.241 4		-0.215 4	-0.224 8	0.317 9	-0.363 2	-0.216 4	-0.362 5	0.211 3	-0.105 5
	X7	-0.413 5	0.167 1		0.065 1	-0.507 1	-0.072 8	0.371 3	0.018 2	0.362 0	-0.162 2	0.242 6
	X8	-0.405 3	0.163 4		0.065 1	-0.507 1	-0.072 8	0.333 1	0.056 3	0.368 2	-0.016 8	0.220 9
	X9	0.168 3	-0.336 0		0.348 8	0.198 7	0.032 0	-0.027 3	0.456 3	0.109 5	0.410 2	-0.372 6
	X10	0.168 6	-0.336 0		0.358 1	0.173 1	0.083 2	-0.028 3	0.424 9	0.103 1	0.407 9	-0.383 7
	X11	0.251 2	-0.179 4		0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0
	X12	0.201 4	-0.198 0		0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0
	X13	0.000 0	0.000 0		0.258 1	0.216 7	0.301 1	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0
	X14	0.000 0	0.000 0		0.258 1	0.216 7	0.301 1	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0
	X15	0.275 2	0.380 0		0.377 3	-0.123 9	-0.068 9	0.051 8	0.442 5	0.416 9	0.113 9	0.002 7
	X16	0.275 2	0.380 0		0.366 5	-0.151 6	-0.1045	0.042 5	0.456 5	0.423 6	0.062 0	0.006 3
2004	X1	-0.386 9	0.114 3	-0.089 0	0.410 6	0.065 4	0.007 1	-0.211 3	0.408 5	0.384 6	0.147 5	0.071 2
	X2	-0.378 8	-0.0277	-0.150 1	0.410 6	0.065 4	0.007 1	-0.231 6	0.423 4	0.388 9	0.078 8	-0.020 0
	X3	0.000 0	0.000 0	0.000 0	-0.108 4	0.150 5	0.616 3	0.311 1	0.247 7	-0.125 8	0.416 6	-0.377 1
	X4	0.000 0	0.000 0	0.000 0	-0.108 4	0.150 5	0.616 3	0.336 1	0.221 1	-0.126 9	0.415 2	-0.377 3
	X5	0.264 9	0.066 2	-0.419 9	-0.256 8	0.004 4	0.1314	-0.292 2	-0.361 3	-0.160 7	-0.519 9	0.055 3
	X6	0.389 0	-0.022 2	-0.059 8	-0.336 9	-0.005 5	0.013 9	-0.258 2	-0.412 5	-0.263 9	-0.434 9	-0.072 8
	X7	0.258 8	-0.014 8	0.537 5	-0.077 9	-0.585 0	-0.040 5	-0.223 7	0.308 2	0.389 6	-0.104 0	-0.140 0
	X8	0.236 2	-0.021 4	0.571 3	-0.077 9	-0.585 0	-0.040 5	-0.223 7	0.308 2	0.378 2	-0.138 4	-0.142 4
	X9	-0.209 6	-0.507 4	0.042 7	-0.255 9	0.355 7	-0.312 4	0.282 4	-0.153 7	-0.377 2	0.155 7	-0.0032
	X10	-0.201 0	-0.523 5	0.037 7	-0.212 3	0.355 9	-0.348 8	0.287 3	-0.143 6	-0.368 7	0.062 8	0.008 8
	X11	0.299 3	0.057 6	-0.277 5	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0
	X12	0.295 9	0.055 4	-0.244 3	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0
	X13	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0
	X14	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0
	X15	-0.224 8	0.470 5	0.131 3	0.410 6	0.065 4	0.007 1	0.374 6	0.088 5	-0.005 3	0.244 4	0.573 4
	X16	-0.224 8	0.470 5	0.131 3	0.410 6	0.065 4	0.007 1	0.370 4	0.027 9	-0.020 5	0.220 9	0.576 8

Note: X1) ratio of *Allactaga sibirica* captured; X2) ratio of *Allactaga sibirica* biomass; X3) ratio of *Dipus sagitta* captured; X4) ratio of *Dipus sagitta* biomass; X5) ratio of *Meriones meridianus* captured; X6) ratio of *Meriones meridianus* biomass; X7) ratio of *Cricetulus barabensis* captured; X8) ratio of *Cricetulus barabensis* biomass; X9) ratio of *Phodopus roborovskii* captured; X10) ratio of *Phodopus roborovskii* biomass; X11) ratio of *Meriones unguiculatus* captured; X12) ratio of *Meriones unguiculatus* biomass; X13) ratio of *Cricetulus eversmanni* captured; X14) ratio of *Cricetulus eversmanni* biomass; X15) ratio of *Citellus dauricus* captured; X16) ratio of *Citellus dauricus* biomass.

and the former two-dimension) and 0.9530 (the prohibited-grazing area), respectively. These results show that the first three-dimension principle components of the variables which were composed by the populations of the rodent's community could show more than 80% in four different disturbance

regions. Through above analysis, the populations were defined whose cumulative percentage was the largest among the populations of the rodent communities. This reflected the sensitivity to the disturbance condition of the dominant population of rodent communities in four disturbance regions.

Table 6 Principal component cumulative percentage in line sites in 2002–2004

Year	Principal component	Farmland area	Rotational-grazing area	Over-grazing area	Prohibited-grazing area
2002	1	0.291 6	0.343 1	0.380 3	0.476 9
	2	0.537 3	0.610 0	0.616 4	0.735 5
	3	0.741 1	0.769 1	0.787 0	0.849 3
	4	0.897 3			
2003	1	0.394 4	0.339 4	0.393 9	0.358 1
	2	0.648 6	0.606 1	0.700 8	0.660 8
	3	0.816 0	0.758 1	0.844 2	0.835 5
2004	1	0.340 0	0.340 2	0.271 1	0.552 7
	2	0.633 4	0.580 3	0.487 3	0.787 1
	3	0.843 3	0.756 6	0.658 0	
	4		0.903 4	0.793 1	

The eigenvectors of every variable on the first three-dimension (Tables 6–8), on the small scale regions (the marking sites) were further analyzed. In the farmland area, the eigenvectors on the first three principal components were as follows: the largest, in 2002, were X7, X8, X9, X10 and X15, X16; in 2003, were X5, X7, X1, X2; in 2004, were X1, X6, X9, X10 and X7, X8. The public item of the largest eigenvectors in three years was X7, which meant *Cricetulus barabensis* was more sensitive to disturbance habitat of the farmland area. In rotational-grazing area, the eigenvectors on the first three principal components were as follows: the largest in 2002 were X9, X10, X13, X14 and X5, X6; in 2003, were X15, X16, X7, X8 and X1, X2; in 2004, were xX1, X2, X7, X8 and xX3, X4. These results showed that every species had reflections on the first three principal components, noted in rotational-grazing area, there were not obviously single population for the sensitivity response of composed populations of the rodent communities. In over-grazing area, the eigenvectors on the first two principal components (more than 80%) were as follows: the largest, in 2002, were X4, X7, X1 and X6; in 2003, were X3, X7, X9 and X16; in 2004, were X15, X16, X2 and X6. These results showed that in three years the species of X3, X4 and X6 were more prominent, which meant the response of the *Dipus sagitta* and the *Meriones meridianus* were more sensitive among the composed populations of the rodent communities. In the prohibited-grazing area, the eigenvectors on the first three principal component were as follows: in 2002, were X4, xX6, X7, X8 and X3, X4; in 2003, were X5, X16, X1, X2 and X3, X4; in 2004, were X2, X7, X5, X6 and X15, X16. These results showed that in three years the performance of X7 was more prominent, which meant in the prohibited-grazing area the roles of the populations of the rodent communities were the same, and the response of the *Cricetulus barabensis* was more sensitive.

At the same time, the sensitive response of every population of rodent communities in four different disturbances was analyzed in the larger scale region (the line sites, 40 hm²), the results was shown as Tables 6 and 7.

It can be seen from Table 6 that in the larger scale region (the line sites, 40 hm²), the results of the PCA analysis showed that the cumulative percentage on the first three principal components in four different disturbance regions in 2002, reached 0.7411 (the first four principal components of the farmland area can reached 0.8973), 0.7691 (the rotational-grazing area), 0.7870 (the over-grazing area, and the first two principal components) and 0.8493 (the prohibited-grazing area), respectively; in 2003, reached 0.8160 (the farmland area), 0.7581 (the rotational-grazing area), 0.8442 (the over-grazing area, and the first two-dimension) and 0.8355 (the prohibited-grazing area), respectively; in 2004, reached 0.8433 (the farmland area), 0.7566 (the rotational-grazing area), 0.7931 (the over-grazing area, and the first four principal components) and 0.7871 (the prohibited-grazing area, and the first two principal components), respectively. From the results, in four different disturbance regions the variables on the first three or four principal components which were composed by the populations of the rodent communities could show more than 76%. Through the analysis, the rodent populations were defined, the cumulative percentage of which on the first three or four principal components was the largest among the populations of the rodent communities, and that reflected sensitivity response to the disturbance condition of the dominant species of rodent communities in four disturbance regions.

The procedure eigenvectors of all of variables were further analyzed and the results were shown in Table 7.

It can be seen from Table 7 that in the larger scale regions (the line sites), in the farmland area, the eigenvectors on the principal component were as follows: the largest, in 2002, were X5, X14, X1, X2, X15, X16 and X5, X6; the largest, in 2003, were X5, X7, X1, X2 and X9, X10; in 2004, were X1, X2, X13, X14 and X5, X6. The performance of xX1, X2 and X5, X6 were more prominent in three years, which meant that *Allactaga sibirica* population and *Meriones meridianus* population were more sensitive to this disturbance habitat in the farmland area; in rotational-grazing area, the eigenvectors on the principal component were as follows: the largest, in 2002, were X3, X4, X6, X15 and X1, X2; the largest, in 2003, were X5, X9, X15, X16, X11, X12 and X7, X8; in 2004, were X1, X2, X5, X6, X13, X14 and X9, X10. These characteristics showed that in rotational-grazing area, the response of every population was the same under this disturbance, there was no visible population; in over-grazing area, the eigenvectors on the principal component were as follows: the largest, in 2002, were X1, X2, X9, X10 and X5, X6; the largest, in 2003, were X3, X4, X13, X16 and X1, X2; in 2004, were X15, X16, X3, X4, X9, X10 and X1, X2. These results showed in three years the performance of X1, X2 and X3, X4 were more prominent, which meant that the visible characteristic was that the response of the *Allactaga sibirica* and the *Dipus sagitta* were more sensitive in over-grazing area under this disturbance condition; in the prohibited-grazing area, the eigenvectors on the principal component were as follows: the largest, in 2002, were X7, X8, X13, X14 and X6; in 2003, were X7, X8,

Table 7 Procedure eigenvector of all of variables in different disturbance areas

2002	Farmland area				Rotational-grazing area				Over-grazing area				Prohibited-grazing area		
	Prin1	Prin2	Prin3	Prin4	Prin1	Prin2	Prin3	Prin4	Prin1	Prin2	Prin3	Prin4	Prin1	Prin2	Prin3
X1	-0.182 0	0.350 1	-0.255 7	0.326 7	0.100 8	0.263 7	-0.445 9	0.413 5	-0.033 5	-0.073 0			0.351 6	-0.049 4	0.360 3
X2	-0.141 2	0.369 7	-0.283 3	0.304 6	0.029 4	0.220 0	-0.478 6	0.413 2	-0.006 3	-0.108 6			0.351 0	0.039 7	0.287 3
X3	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	-0.361 1	-0.124 9	0.244 7	-0.375 5	-0.191 8	-0.186 9		0.316 0	-0.230 3	0.211 9
X4	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	-0.355 4	-0.158 6	0.245 8	-0.402 1	-0.153 5	-0.105 4		0.303 5	-0.233 5	0.133 1
X5	-0.377 3	0.094 6	-0.002 7	0.409 1	0.269 4	-0.325 8	-0.191 7	0.190 0	-0.108 5	0.514 2			0.351 4	-0.037 3	-0.374 2
X6	-0.253 7	-0.216 5	0.079 5	0.462 2	0.277 7	-0.327 9	-0.122 6	0.172 7	-0.102 6	0.531 0			0.220 3	0.083 2	-0.700 1
X7	0.289 2	-0.329 6	0.152 6	0.307 9	0.292 3	-0.249 3	0.202 3	0.370 3	-0.058 8	-0.294 3			-0.412 6	-0.068 3	-0.051 2
X8	0.289 1	-0.344 4	0.133 7	0.272 7	0.283 4	-0.248 0	0.190 6	0.365 3	-0.051 0	-0.242 9			-0.402 1	-0.099 3	0.099 3
X9	0.301 6	0.338 9	0.110 2	0.178 3	-0.189 5	0.300 0	0.193 2	-0.074 6	0.470 7	0.061 1			0.203 0	0.367 4	-0.000 6
X10	0.342 4	0.280 2	0.222 9	0.124 1	-0.172 6	0.277 2	0.139 4	-0.051 2	0.472 8	0.074 4			0.105 2	0.471 1	-0.109 5
X11	0.216 6	-0.182 3	-0.274 1	0.301 7	0.301 8	0.245 5	0.117 7	0.000 0	0.000 0	0.000 0			0.000 0	0.000 0	0.000 0
X12	0.258 9	-0.174 1	-0.288 0	0.241 8	0.299 6	0.231 9	0.146 5	0.000 0	0.000 0	0.000 0			0.000 0	0.000 0	0.000 0
X13	0.347 2	0.213 5	-0.267 7	0.150 5	-0.177 6	0.018 2	-0.262 4	-0.092 1	0.139 2	0.156 6			-0.048 8	0.492 4	0.196 4
X14	0.349 1	0.210 1	-0.268 8	0.148 4	-0.176 8	0.015 4	-0.261 3	-0.021 9	-0.241 1	0.452 7			-0.051 2	0.516 0	0.178 4
X15	0.064 8	0.235 5	0.470 7	0.067 1	0.236 7	0.348 0	0.147 4	0.032 1	0.440 2	0.055 5			0.000 0	0.000 0	0.000 0
X16	0.064 8	0.235 5	0.470 7	0.067 1	0.226 7	0.318 5	0.268 2	0.032 1	0.440 2	0.055 5			0.000 0	0.000 0	0.000 0
2003	Farmland area				Rotational-grazing area				Over-grazing area				Prohibited-grazing area		
	Prin1	Prin2	Prin3	Prin4	Prin1	Prin2	Prin3	Prin4	Prin1	Prin2	Prin3	Prin4	Prin1	Prin2	Prin3
X1	0.231 1	0.384 7	-0.033 9	0.305 8	-0.152 9	-0.381 4			-0.019 8	-0.243 6	0.528 6		0.330 9	-0.161 3	0.382 4
X2	0.216 2	0.380 6	-0.040 0	0.291 6	-0.189 5	-0.364 5			0.091 7	-0.279 3	0.514 5		0.277 2	-0.108 7	0.426 6
X3	0.000 0	0.000 0	0.000 0	-0.142 2	0.417 7	-0.109 6			-0.418 0	-0.017 5	-0.026 9		0.242 3	-0.301 9	0.183 8
X4	0.000 0	0.000 0	0.000 0	-0.188 5	0.295 5	-0.059 1			-0.409 0	0.037 6	-0.073 0		0.238 7	-0.304 2	0.194 2
X5	0.339 0	-0.204 3	-0.073 1	0.448 1	0.004 6	0.041 2			0.288 9	0.045 4	-0.374 1		0.398 8	-0.003 1	-0.380 4
X6	0.272 9	-0.335 6	0.053 5	0.375 5	-0.103 1	0.162 7			0.341 4	0.050 5	-0.360 0		0.257 8	0.069 5	-0.569 3
X7	-0.352 0	-0.132 6	0.109 2	-0.136 4	-0.286 0	-0.003 1			0.310 1	-0.186 8	0.019 5		-0.460 2	-0.115 2	0.101 6
X8	-0.318 6	-0.158 8	0.212 2	-0.216 8	-0.250 9	0.023 3			0.312 9	-0.220 0	-0.053 2		-0.474 0	-0.037 8	0.078 0
X9	0.077 6	0.302 7	0.512 3	-0.407 1	-0.157 1	0.067 0			0.346 1	0.044 3	0.185 9		0.095 4	0.442 8	0.249 1
X10	0.060 3	0.256 1	0.549 8	-0.359 6	-0.227 7	0.142 5			0.341 1	-0.026 6	0.159 6		-0.007 5	0.413 7	0.176 9
X11	-0.200 8	0.278 5	-0.433 3	0.168 7	0.164 4	0.535 6			0.000 0	0.000 0	0.000 0		0.000 0	0.000 0	0.000 0
X12	-0.271 3	0.261 7	-0.363 6	0.168 7	0.164 4	0.535 6			0.000 0	0.000 0	0.000 0		0.000 0	0.000 0	0.000 0
X13	-0.317 6	0.238 7	0.060 4	0.000 0	0.000 0	0.000 0			0.078 4	0.454 0	0.159 1		0.117 5	0.439 7	0.098 1
X14	-0.286 7	0.244 5	0.134 2	0.000 0	0.000 0	0.000 0			0.081 8	0.444 8	0.148 5		0.114 1	0.445 4	0.110 1
X15	0.300 5	0.192 7	-0.120 2	-0.014 0	0.444 9	-0.187 0			0.046 9	0.408 6	0.186 6		0.000 0	0.000 0	0.000 0
X16	0.296 9	0.230 2	-0.107 6	-0.078 7	0.441 6	-0.209 6			0.062 4	0.446 6	0.186 8		0.000 0	0.000 0	0.000 0
2004	Farmland area				Rotational-grazing area				Over-grazing area				Prohibited-grazing area		
	Prin1	Prin2	Prin3	Prin4	Prin1	Prin2	Prin3	Prin4	Prin1	Prin2	Prin3	Prin4	Prin1	Prin2	Prin3
X1	0.425 6	-0.113 8	-0.076 3	0.412 2	0.107 8	-0.130 6	0.103 0	-0.142 0	-0.069 9	0.106 2	0.566 1		0.109 0	0.625 3	-0.074 4
X2	0.431 4	-0.107 3	-0.006 9	0.423 1	0.093 1	-0.159 7	0.119 5	-0.151 2	-0.073 1	0.105 4	0.557 4		0.141 6	0.612 4	-0.023 3
X3	0.000 0	0.000 0	0.000 0	-0.248 5	0.227 1	-0.069 2	0.495 7	0.032 3	-0.428 0	-0.267 2	0.120 9		-0.242 4	0.063 9	0.650 6
X4	0.000 0	0.000 0	0.000 0	-0.295 6	0.299 9	-0.100 5	0.343 6	-0.060 2	-0.362 4	-0.281 3	0.070 5		-0.244 7	0.036 4	0.652 4
X5	0.020 0	0.288 3	-0.448 7	0.078 6	-0.530 6	0.063 5	-0.021 4	0.282 1	0.258 7	-0.310 0	-0.097 4		-0.404 9	0.052 2	-0.134 7
X6	-0.247 9	0.199 2	-0.365 6	0.047 4	-0.532 6	0.047 6	-0.105 4	0.272 6	0.289 7	-0.281 5	-0.093 5		-0.384 8	-0.215 1	-0.167 8
X7	-0.263 2	-0.285 5	0.317 1	0.310 6	-0.014 4	-0.237 8	0.152 4	0.156 5	0.350 4	0.129 0	0.183 7		0.371 7	-0.268 3	0.083 8
X8	-0.272 8	-0.280 0	0.277 8	0.310 6	-0.014 4	-0.237 8	0.152 4	0.157 4	0.341 4	0.140 4	0.171 2		0.364 4	-0.310 3	0.074 0
X9	0.355 6	-0.061 7	0.244 1	0.017 2	0.304 7	-0.185 0	-0.527 8	-0.242 4	0.086 4	0.404 9	0.024 7		0.000 0	0.000 0	0.000 0
X10	0.307 1	-0.051 8	0.301 8	-0.070 0	0.269 2	-0.207 9	-0.520 9	-0.190 1	0.145 7	0.425 2	-0.242 5		0.000 0	0.000 0	0.000 0
X11	0.123 6	0.385 2	0.301 1	0.000 0	0.000 0	0.000 0	0.000 0	0.009 0	0.258 5	-0.226 8	0.305 3		0.000 0	0.000 0	0.000 0
X12	0.109 4	0.372 9	0.318 7	0.000 0	0.000 0	0.000 0	0.000 0	0.009 0	0.258 5	-0.226 8	0.305 3		0.000 0	0.000 0	0.000 0
X13	0.028 2	0.420 5	0.117 7	0.042 2	0.139 8	0.575 5	-0.032 1	0.381 8	-0.233 3	0.159 8	0.049 6		0.370 4	0.097 5	0.211 6
X14	0.005 4	0.433 6	0.104 2	0.037 6	0.145 8	0.573 0	-0.031 2	0.381 8	-0.233 3	0.159 8	0.049 6		0.359 6	-0.042 8	0.203 6
X15	0.298 6	-0.130 5	-0.238 5	0.375 7	0.183 6	0.225 7	0.034 0	0.426 9	-0.106 0	0.232 8	0.087 3		0.000 0	0.000 0	0.000 0
X16	0.298 6	-0.130 5	-0.238 5	0.388 6	0.180 9	0.187 7	0.015 8	0.424 5	-0.052 0	0.250 2	0.097 8		0.000 0	0.000 0	0.000 0

Note: X1–X16 are the same as Table 5.

X9, X14 and X2, X6; in 2004, were X5, X6, X3, X1 and X3, X4. These results showed that in three years the performances of X7, X8 were more prominent, which meant that the

same characteristic of three years was that the response of the *Cricetulus barabensis* was more sensitive in the prohibited-grazing area under this disturbance condition.

Table 8 Comprehensive analysis of sensitive response of populations of rodent communities under different disturbance on two scales in three years

Year		Marking sites				Line sites			
		Farmland area	Rotational-grazing area	Over-grazing area	Prohibited-grazing area	Farmland area	Rotational-grazing area	Over-grazing area	Prohibited-grazing area
2002	Cumulative percentage	0.881 5	0.906 5	0.800 5	0.919 6	0.897 3	0.769 1	0.787 0	0.849 3
	P1	X7 X8	X9 X10	X4 X7	X6 X16	X5 X14	X3 X4	X1 X2	X7 X8
	P2	X9 X10	X13 X14	X1 X6	X7 X8	X1 X2	X15 X16	X9 X10	X13 X14
	P3	X15 X16	X5 X6		X3 X4	X15 X16	X1 X2	X5 X6	X5 X6
	P4					X5 X6			
2003	Cumulative percentage	0.768 8	0.860 6	0.852 6	0.921 8	0.816 0	0.890 1	0.844 2	0.835 5
	P1	X5 X8	X15 X16	X3 X7	X5 X16	X5 X7	X5 X9	X3 X4	X7 X8
	P2	X1 X15	X7 X8	X9 X16	X1 X2	X1 X2	X15 X16	X13 X16	X9 X14
	P3		X1 X2		X3 X4	X9 X10	X11 X12	X1 X2	X2 X6
	P4						X7 X8		
2004	Cumulative percentage	0.856 0	0.820 5	0.822 9	0.953 0	0.843 3	0.903 4	0.793 1	0.787 1
	P1	X1 X6	X1 X15	X15 X16	X2 X7	X2 X1	X1 X2	X15 X16	X5 X6
	P2	X9 X10	X7 X8	X2 X6	X5 X6	X13 X14	X5 X6	X3 X4	X1 X2
	P3	X7 X8	X3 X4		X4 X3	X5 X6	X13 X14	X9 X10	
	P4						X9 X10	X1 X2	

Note: X1–X16 are the same as Table 5.

The comprehensive analysis was further conducted in Tables 5 and 7 and the results were shown in Table 8.

It can be seen from Table 8 that in the small scale regions (the marking sites, 0.96 hm²), from 2002 to 2004, the prominent characteristic of the three years was that the response of the dominant populations of rodent communities to the different disturbances were as follows: in the farmland area, the prominent performance was the *Cricetulus barabensis* population in the small scale region in three years, and the eigenvectors were all very large on the first, second and third principal components, and it was showed that *Cricetulus barabensis* population was most sensitive to this disturbance condition after the reclamation of native vegetation of the desert ecological system. It meant that the *Cricetulus barabensis* presence and the rise of its number meant the instruction population to this type of disturbance reclamation; in the prohibited-grazing area, under this disturbance the prominent performance was the *Cricetulus barabensis* population and the *Citellus dauricus* population, the eigenvectors of them were all large on the first principal components; in rotational-grazing area, each population had performance on the first three principal components. It was showed that there was no prominent population among the rodent populations which were composed by the rodent communities under the disturbance of rotational-grazing. It was seen from the serious disturbance type of over-grazing that sensitive response of all populations in the small scale region in three years had a prominent characteristic which was the eigenvectors of the *Dipus sagitta* population and the *Citellus dauricus* population on the first and the second principal components had the grater performance, which meant that the *Dipus sagitta* population and the *Citellus dauricus* population have more sensitive response to this type of the disturbance.

In the larger scale regions (the line sites, 40 hm²), in farmland area, the prominent performance was the sensitive response of the *Allactaga sibirica* and the *Meriones meridianus* populations, the eigenvectors of them were all very large at the first, second and third principal components in three years. They were obviously different from the sensitivity of the farmland area of the small scale regions; under this type of the disturbance in prohibited-grazing area in three years, the *Cricetulus barabensis* population performs prominent sensitive response; in the over-grazing area, in three years on the larger scale the obviously consistent characteristic was that the sensitive response of the *Allactaga sibirica* population and the *Dipus sagitta* population was strong; in the rotational-grazing area, there was no consistent dominant population performing prominent sensitivity response on two scales in three years, and the eigenvectors of the first three or four principal components contain many populations response. Connell (1978) advanced famous Intermediate Disturbance Hypothesis, which meant that moderate disturbance led to the highest diversity, because under the moderate disturbance, the developments of some new species or immigrate species had not been completed and another disruption had already happened, so new dominant species always could not product in the community, thus maintaining higher species diversity. Different populations had different sensitivity to the disturbance (Ma et al., 2004). It was seen from the analyzed results that in PCA order, each rodent population which composed the communities had the performance on the first three principal components, and there are no one or two obviously dominant population, and could maintain higher species diversity of the community. Studies on the theories and the practice showed that biodiversity had the positive correlation with the

function (stability) of the ecosystem (Li, 2004). This also explained that under this vegetation condition of the typical desert ecosystem, rotational-grazing which was the moderate disturbance condition made the rodent communities keep stable community pattern.

5 Discussion

The human activity disturbance was distinctive with the natural disturbance, which mainly resulted from the production, life and other public activities of human being, and had various negative influences on natural environment and the ecosystem. The researches on the human activity disturbance and its influence on the ecosystem have already become the focus of modern ecology (Fu et al., 2001). The disturbance appeared in all levels from the individual to the landscape. The disturbance was one kind of main ecology process of the landscape, and it was one of main origins of landscape heterogeneity. The disturbances from different scales, nature and origin were the foundation of the landscape structure and the function changing (Li et al., 2003). In the modern world, the development tendency of ecology was to thoroughly study and promulgate that the habitat fragmentation and the landscape patch have an influence on the animal community in different scales, and the response of the animal community to the ecological disturbance (Lindenmayer et al., 2000; Lomolino and Perault, 2000; Boulinier et al., 2001; Davies et al., 2001; Donovan and Lamberson, 2001; Hames et al., 2001; Mackey and Currie, 2001). Nupp and Swihart (2000) pointed out that human being caused the natural habitat fragmentation effect always on the fragmentation of the natural community's structure and the function as well as the sensitive species in the fragmentation. The habitat fragmentation effect was regarded to change main species. According to their solitary to habitat area, habitat patch and their sensibility to edge patch proportion changed, it was supposed that the sensitive responses of the forest land patch were opposite to the size change of six small mammal individuals, and carried on the examination. Hames et al. (2001) pointed out that the habitat fragmentation caused by humanity was connected with the quantity dropping of many sensitive species population. The Meta-population Dynamics had already found the process of the driving pattern that sensitive species led to fragmentation reflection, but forecast or examination of this theory was very limited in the vertebrate.

There are many reports on the issue that the habitat fragmentations led to the change of animal community pattern and its species changed after the human activity disturbance (Jiang et al., 2003), especially, many reports on the studies of rodent and birds in tropical rain forest or forest land (Chen and Dong, 2003). As population pressure and unreasonable use, the desert ecosystem of China was seriously disturbed. The results of this research showed the pattern and change characteristic of the rodent communities and its main populations' sensitive response to different disturbance type under four kinds of different disturbance conditions. The four kinds

of disturbance types are farmland, rotational-grazing, over-grazing and prohibited-grazing, which were only one kind of qualitative classification of disturbance intensity. Therefore, the relationships among the quantitative study and the four kinds of disturbance types and the rodent community pattern, process and scale will be further researched.

The ecological environment sensitivity refers to the sensitive degree of the ecosystem due to each kind of variation and the humanity disturbing, namely, meeting the disturbance, the probability frequency of the ecological environment problems appear (Liu et al., 2003). Under the natural condition, each kind of ecology process was maintaining one kind of relatively stable coupling relationships, and guaranteeing the ecosystem relatively stable. When the external disturbing surpassed the certain limit, this kind of coupling relationships would be broken. Some ecological processes tended to the inflation, and could cause the serious ecological environment problems (Liu et al., 2003). When human disturbing, appearing or vanishing of one creature or a kind of creature or the change of the quantity exceptionally in this region all related with the environmental condition, which was the response of the creature adapts to the environmental variation or not (Ma et al., 2004). The ecological environment sensitivity researches at present mainly focus on the sensitivity of the acid rain and burning down (Tao and Feng, 1999; Pulliam et al., 1992), other ecological environment questions about sensitivity research were very few (Ouyang et al., 2000). At present, international reports on the rodent community sensitivity responds to the disturbance were also very few, the researches on the ecological sensitivity always concentrates on some ecological questions or the integrated national scale (Ouyang et al., 2000; Wang et al., 2001) while less on the ecological sensitivity research at the provincial level (Liu et al., 2003). Using the characteristic parameter of the community structure as ecological monitoring indicators, such as diversity, richness, evenness, dominance and similarity of the community and so on, can exactly reflect the relativity of the creature adaptations making each kinds of change of the creature community (Fu et al., 2001). In this paper, the richness and biomass rate of composed species of the rodent communities under the different disturbances were chosen, using the PCA method to analyze the sensitive response of various populations to the different disturbance types, namely using the community structure characteristic parameter to reflect the relativity of the creature adaptation. The PCA analysis method was successful one which was widely applied to the quantity classification and the spatial arrangement (Yang, 1981), and it aims at that the main function variables in the lower-dimensional space were found from the massive information in the multi-dimensional space through dimensionality reduction. The results of the PCA method used to find the largest eigenvectors on the first three principal components of each population in the rodent communities, so determined sensitivity response characteristic of main populations under different disturbances, and the results perfectly showed that using this method was correct and feasible. The response

strength of each community structure index after different disturbance strength for quantity needs further research and analysis.

The scale question was one of natural sciences crucial questions (Jiang et al., 2003), and was focus question in the ecosystem (Levin, 1992). The scale was spatial resolution or time unit of research object (object or process) (Xiao et al., 1997), also signed the understanding level of the research object. In the ecological research, the spatial scale meant the area size of the research ecosystem or the spatial resolution level of unit (Chen et al., 2002). The scale was very important in the spatial analysis of the ecosystem succession, but how to correctly determine the space and the time scale of ecosystem succession had not been a thorough discussing and research domain (Jiang et al., 2003). So far, the results of the majority scientific research originated from the small scale studies (point scale, local scale), the results on these scales had reflected some certainly great scale questions in some kind of degree, and its accuracy had not been clear (Li et al., 2003). Ding (2004) believed that the exchange of the information existed between the different hierarchies of the ecological system; the exchange constituted the relationship of different hierarchies, and made the scale up and down being possible. The scale choice frequently was completed through the limitation of the person's sensation ability or the technical logic relationships. For a long time, the community ecologists frequently observed the phenomenon that the community structure was being destroyed by the formidable natural forces from outside of the community. The community scale was close to the scale of human sensitive organ; therefore, the influence of the disturbance was obvious on this scale (Wu, 2000).

In the paper, the community was taken as the observation scale, and there are two observation scales as the spatial scale, one was the small marking site (area was 0.95 hm²), another was the large line site (area was 10 km²). The selection of the two different observation scales on the basis of the sampling technology can be completed in the field and person's sensation ability. Used mark-recapture method in the marking site and the trap-day method in the line site to investigate, the difference of the capture ratio of the two methods was not remarkable after variance analysis ($P > 0.05$). Therefore, the abundance (capture number) of composed species in the rodent community was used to analyze the community pattern and the change tendency in these two kinds of observation scales. It can be seen from the study results that in the environments of the same type disturbance, in two observing scales, although the composition pattern and its sensitivity response of the dominant populations of communities had some differences, according to general analysis there had been a consistent feature, especially in the rotational-grazing, the prohibited-grazing and the farmland areas, the performance of the sensitivity response of dominant populations was more consistent. On the one hand, the result reflected that the desert ecosystem such as Alashan was consistent in a larger region, and the dominant population of the rodent

communities distributed consistently, so the scale effect of the tendency of the community pattern changing was not notable in the change of these two scales; on the other hand, this also meant that the spatial scale effect of the community pattern changing must be researched thoroughly with comparison of the larger spatial scale or more spatial scales in this ecological condition, especially needing to apply 3S (GPS, RS, GIS) technology to research the change characteristic of the community pattern in a point scale, the local scale and the macroscopic scale.

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