

# Niche characteristics of rodents by diverse disturbance in Alashan desert, Inner Mongolia, China

FU Heping, WU Xiaodong (✉), YANG Zelong

College of Ecology and Environmental Science, Inner Mongolia Agricultural University, Hohhot 010019, China

© Higher Education Press and Springer-Verlag 2007

**Abstract** Four diverse disturbance types, namely, farmland, rotationally grazed grassland, overgrazed grassland and forbidden grazing grassland, were identified in the Alashan desert region of Inner Mongolia. Rodents were sampled in April, July and October in 2002 and 2003 using the trap-day method. Their spatial and temporal niches among the four disturbance types were assessed using the Shannon-Wiener niche breadth index and the Pianka niche overlap index. The Shannon-Wiener niche breadth index was the highest for *Allactaga sibirica* and *Meriones meridianus* (0.925 and 0.908, respectively), intermediate for *Cricetulus evermanni*, *Phodopus roborovskii* and *Citellus dauricus* (0.789, 0.782 and 0.711, respectively), and lowest for *Cardiocranius paradoxus* (0.003). The Pianka niche overlap indices of six-paired species were the highest and varied from 0.900 to 1.000, suggesting their spatial niche overlapped almost completely. Conversely, the spatial niche overlap index for *Meriones unguiculatus*, *Cardiocranius paradoxus*, and *Salpingotus kozlovi* was zero, thus indicating a complete absence of competition among them. In addition, the temporal niche breadth and overlap indices varied greatly in relation to disturbance types and season. The level of temporal niche overlap in spring and autumn was low while in summer it was high. For all disturbance types and for each season, the temporal niche overlap index of *Meriones meridianus* and *Cricetulus barabansis* was always highest but for *Meriones unguiculatus* and *Salpingotus kozlovi* always lowest.

**Keywords** rodent, niche, habitats, disturbance, desert, Alashan

## 1 Introduction

The studies on niche had attracted attention of many ecologists (Abrams, 1980; Petraitis, 1981; Wang et al., 1984;

Translated from *Acta Ecologica Sinica*, 2005, 25(10): 2,637–2,643  
[译自: 生态学报]

E-mail: wuxiaodong\_hgb@163.com; fuheping@126.com

Peng, 1989; Jhon and James, 1990; Putman and Wratten, 1990; Chen and Zhou, 1995; Shang, 1998; Sun, 2001; Zhao et al., 2001; Lin et al., 2002; Shang, 2002; Zhang et al., 2002a). A lot of studies had concentrated on multi-dimensional niche analysis of different plant population in China (Wang, 1984; Peng, 1989; Chen et al., 1995; Lin et al., 2002; Zhang et al., 2002b), which provided scientific basis for different plant resources utilized reasonably. The studies on niche did not separate from resources utilized generally. The Alashan Desert of Inner Mongolia, located in center of Asia, was a typical temperate zone of desert and arid vulnerable ecosystem. Over there, the condition of ecological environment was very bitter, and the quantity and quality of utilized resources for animals were more significant than moist area and semi-arid area in Inner Mongolia. Therefore, the distribution of rodent possessed the region characteristic (Zhao, 1981; Ma et al., 1987; Wu et al., 2003).

Recently, continual aggravated human disturbance made desert grievous in the region; therefore, the population component and community pattern of animals relied on plant had been influenced significantly. Disturbance always influenced ecological process, and the ecological effects from disturbance always were presented by ecological process. The study results showed that the prominent function of disturbance caused the change of serious resources of ecosystem and reordering of ecosystem structure (Chen and Fu, 2000). The ecological effects of disturbance on environment were either advantage or disadvantage due to not only the characteristic of disturbance but also objects disturbed. Appropriate disturbance made biodiversity improve and bio-resources protected. Therefore, different disturbance levels to habitats of animals were important factors that affected animals' distribution. The same properties disturbance could conduct different characteristics and effects when it was studied by different studied scales. Therefore, the properties, characteristics and principle of occurring and expanding of disturbances could be studied by analyzing the effects of disturbance.

In this paper, four kinds of different disturbances were selected in Alashan Desert of Inner Mongolia, in which

the niche and the relationship between it and the utilized resources of rodent were studied, and status and function of rodent population in communities under different disturbance were analyzed. This would provide basic data for revealing community pattern and dynamic of desert rodent, ecological process of biodiversity of desert region under different disturbances.

## 2 Natural conditions and methods

### 2.1 Natural conditions

The studied area (104°10′–105°30′E, 37°24′–38°25′N), natural desert landscape, is located in Southern Alashan zuoqi of Inner Mongolia and in Western Tenggel Desert. Vegetation on studied area was few and scattered. Its structure was more monotonous, and coverage was lower as 1%–20%. The plant species was poor, which chiefly includes shrub, half-shrub, small shrub, 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 principle, 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 is 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 temperature was 42°C. Annual 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 3,000 to 4,700 mm. The soil was brown desert soil with weak eluviations. The soil quality was lax and barren. The content of top soil organic was from 1% to 1.5% with a lot of dissolubility salt.

Based on different utilized levels of grassland, four habitats were selected for setting up sites, which were by different disturbance. The conditions of four habitats were 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 *Haloxydon ammodendron*, *Calligonum mongolicum* and the perennial grass of *Hedysarum scoparium*, *Medicago sativa* etc. as principal, with the annual weed of *Nanophyton erinaceum*, *Bassia dasyphyllum* 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 hm<sup>2</sup>, 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 aciphilla* etc. of perennial small shrub, and

*Peganum 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 were *Nitraria* spp and *Zygophyllum pterocarpum*, with the *Reaumures soongorica*, *Oxytropis aciphilla*, *Cleistogenes squarosa* etc. of perennial plant and *Suaeda glauca*, *Plantago lessingii* etc. of annual plant 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 mainconstructive species were *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 flacidum*, with *Cleistogenes squarosa*, *Bassia dasyphyllum* 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%.

### 2.2 Methods

According to different seasons, the sixteen regular sites were set up in the four different disturbance habitats average in April, July and October in 2002 and 2003, when it represented spring, summer and autumn, respectively. Rodents were captured in the sites by trap-day that the traps were set up as each away 5 m, line away 50 m, and remained 24 h. There were four sites in each disturbance habitat, and the area of each site was 10 hm<sup>2</sup>. There were 48,000 of traps set up in 96 sites, and 3,201 samples were captured in two years, which belong to *Sciuridae* (one kind of species), *Dipodidae* (four kinds of species), *Cricetidae* (five kinds of species) and *Muridae* (one kinds of species), total 11 kinds of species.

It can be seen from Table 1 that there were significant difference in vegetation and soil that were utilized resources for animals from four different disturbance habitats. Therefore, the four different disturbance habitats were as four grads utilized resources of rodents, the spatial niche of which and its season characteristic were analyzed. The measuring formulas were as follows.

Niche breadth was measured by Shannon-Wiener index (John and James, 1987; Sun, 2001)

$$B_i = \frac{\lg \sum N_{ij} - (1/\sum N_{ij})(\sum N_{ij} \lg N_{ij})}{\lg r}$$

where  $B_i$  is the niche breadth index of  $i$  species;  $N_{ij}$  is the grade value of  $i$  species utilized  $j$  resource (i.e. the average value of number of rodent recaptured in site);  $r$  is grade number of utilized resources; values of  $B_i$  are between 0 and 1.

**Table 1** Average value of captured number of desert rodents in sites, and niche breadth indices in spatial and season of rodents in different disturbance dimension in Alashan desert

Habitats	(1)	(2)	(3)	(4)	$B_i$			
Species	(12,000 <sup>a)</sup> )	(12,000)	(12,000)	(12,000)	Spatial	Spring	Summer	Autumn
<i>Citellus dauricus</i>	0.25 <sup>b)</sup>	0.79	0.42	0.00	0.711	0.428	0.686	0.000
<i>Allactaga sibirica</i>	2.29	0.92	2.17	3.79	0.925	0.908	0.799	0.809
<i>Dipus sagitta</i>	0.00	5.71	12.13	0.63	0.551	0.608	0.465	0.515
<i>Meriones meridianus</i>	18.33	7.46	4.54	12.75	0.908	0.717	0.978	0.876
<i>Meriones unguiculatus</i>	1.92	0.17	0.00	0.00	0.202	0.377	0.179	0.000
<i>Cricetulus barabansis</i>	15.21	1.00	0.79	11.67	0.669	0.498	0.726	0.688
<i>Cricetulus eversmanni</i>	0.21	0.08	0.63	0.13	0.789	0.487	0.670	0.536
<i>Phodopus roborovskii</i>	1.29	15.67	7.75	3.46	0.782	0.592	0.732	0.820
<i>Cardiocranius paradoxus</i>	0.00	0.00	0.04	0.00	0.003		0.000	
<i>Salpingotus kozlovi</i>	0.00	0.00	0.33	0.08	0.345	0.000	0.407	0.000
<i>Mus musculus</i>	0.38	0.04	0.33	0.00	0.632	0.424	0.370	0.469
Total	957	764	699	781				
Numbers of sites	24	24	24	24				

Note: (1) Farmland area; (2) rotational grazing area; (3) over grazing area; (4) forbidden grazing area;

<sup>a)</sup> Number of trap-day; <sup>b)</sup> averages of captured numbers in sites;  $B_i$ ) niche breadth indices.

Niche overlap was measured by Pianka index (Putman and Wratten, 1994)

$$C_p = \sum P_{ij}P_{kj} / (\sum P_{ij}^2 \sum P_{kj}^2)^{1/2}$$

where  $C_p$  is the niche index;  $P_{ij}$  and  $P_{kj}$  are the ratios of  $i$  species and  $k$  species utilized  $j$  resources grade, respectively. The values of  $C_p$  are between 0 and 1.

In the process of calculating data, to spatial niche breadth index and niche overlap index, the data in the same disturbance sites were merged in two yearly; to niche breadth index and niche overlap index in different seasons, the data in the same disturbance sites in the same season were merged in two annually.

### 3 Results

#### 3.1 Spatial niche breadth and its season characteristic

Average value of captured number of desert rodents in sites, and niche breadth indices in spatial and different seasons of rodents by different disturbance dimension in Alashan desert were listed in Table 1. It was seen from Table 1 that the niche breadth indices of *Allactaga sibirica* and *Meriones meridianus* were the highest, reaching 0.925 and 0.908, respectively. Those of *Cricetulus eversmanni*, *Phodopus roborovskii*, and *Citellus dauricus* were secondary, reaching 0.789, 0.782 and 0.711, respectively. That of *Cardiocranius paradoxus* was the lowest as 0.003, equal to 0 nearly. Those of others were between 0.202 and 0.669.

The results of niche breadth indices showed that the adaptability of *Allactaga sibirica* and *Meriones meridianus* to four different disturbance habitats was better, and they utilized different grades sufficiently. They were the species with better adaptability to different disturbance habitats in desert. On the contrary, the level of *Cardiocranius paradoxus* utilized

resources was narrower, and it was only captured in site (3) over two years. This result showed that the species utilized resources in unity.

In spring, the niche breadth index of *Allactaga sibirica* was the highest, reaching 0.908; that of *Meriones meridianus* was the secondary, reaching 0.717; that of *Salpingotus kozlovi* was the lowest as 0. It needs to explain that the working time in spring of this study was between April, 5 and 12, but *Cardiocranius paradoxus* was never captured by 12,000 of traps over two years. This result showed that the species had been in the period of hibernation in this period.

In summer, the niche breadth index of *Meriones meridianus* was the highest, reaching 0.978; those of *Allactaga sibirica*, *Phodopus roborovskii*, and *Cricetulus barabansis* were the secondary, reaching 0.799, 0.732 and 0.726, respectively. That of *Cardiocranius paradoxus* was the lowest as 0. This result was more significant change than that of spring.

In autumn, the niche breadth indices of *Meriones meridianus*, *Phodopus roborovskii*, and *Allactaga sibirica* were the highest, reaching 0.876, 0.820 and 0.809, respectively. The working time in autumn of this study was between October, 5 and 12, but *Cardiocranius paradoxus* was never captured by 12,000 of traps over two years. This result showed that the species had been in the period of hibernation in this period. Therefore, the niche breadth indices of *Citellus dauricus*, *Meriones unguiculatus*, and *Salpingotus kozlovi* were the lowest as 0 in autumn in Alashan desert. This result made a distinction among autumn and spring, summer. The niche of rodents appeared significant differentiation.

Summarizing, under four different disturbance, in three different seasons of spring, summer and autumn, the changed orders of niche breadth indices of desert rodents were as follows: in spring, *Allactaga sibirica* > *Meriones meridianus* > *Dipus sagitta* > *Phodopus roborovskii* > *Cricetulus barabansis* > *Cricetulus eversmanni* > *Citellus dauricus* > *Mus musculus* > *Meriones unguiculatus* > *Salpingotus*

*kozlovi*; in summer, *Meriones meridianus* > *Allactaga sibirica* > *Phodopus roborovskii* > *Cricetulus barabansis* > *Citellus dauricus* > *Cricetulus evermanni* > *Dipus sagitta* > *Salpingotus kozlovi* > *Mus musculus* > *Meriones unguiculatus* > *Cardiocranius paradoxus*; in autumn, *Meriones meridianus* > *Phodopus roborovskii* > *Allactaga sibirica* > *Cricetulus barabansis* > *Cricetulus evermanni* > *Dipus sagitta* > *Mus musculus* > *Citellus dauricus*, *Meriones unguiculatus*, *Salpingotus kozlovi*. Therefore, the niche breadth indices of desert rodents were significantly alterable with the change seasonally under different disturbance. Although the results had not separated from ecology and biological characteristic of different rodent species, yet it was important function that was not only relative richness change of utilized resources in different seasons but also distribution pattern of utilized resources under different disturbance. As for distribution pattern how to achieved, it would be needed to study in a deep-going way.

### 3.2 Spatial niche overlap and its season characteristic

Niche overlap indices in spatial of rodents by different disturbance dimension in Alashan desert were listed in Table 2. It can be seen from Table 2 that the niche overlap indices of *Citellus dauricus* and *Phodopus roborovskii*, *Dipus sagitta* and *Cardiocranius paradoxus*, *Meriones meridianus* and *Cricetulus barabansis*, *Cricetulus evermanni* and *Cardiocranius paradoxus*, *Cricetulus evermanni* and *Salpingotus kozlovi*, *Cardiocranius paradoxus* and *Salpingotus kozlovi* were the highest, all of them were greater than 0.9, and closed to 1, which showed that their spatial niche were completely overlap. This result also showed that each double-species above utilized resources unanimously as well as adapted different disturbance in desert habitats. According to niche theory, more than two species would coexist, those niche were same under different resources, meaning that their competition weakened each other. However, the different species of above the six double-species coexisted, which showed that different disturbances that perhaps lead to change of nutrition niches caused the result of niche high overlap. It was found in Table 2 that the spatial niche overlap indices of *Meriones unguiculatus*,

*Cardiocranius paradoxus* and *Salpingotus kozlovi* were zero, which showed that the three species utilized habitat resources differently, and had no competition each other. From the ecology and biological characteristics of the three species, *Meriones unguiculatus* moved in day, on the contrary, *Cardiocranius paradoxus* and *Salpingotus kozlovi* moved in night (Zhao, 1981; Ma et al., 1987); from body size, there was significant difference among *Meriones unguiculatus* and *Cardiocranius paradoxus*, *Salpingotus kozlovi* (Zhao, 1981; Ma et al., 1987). Above characteristics were the important factors to reduce niche overlap indices.

The niche overlap indices of desert rodent in different seasons under different disturbance were listed in Table 3. Seen from the Table 3, in spring, the niche overlap indices of *Dipus sagitta* and *Cricetulus evermanni*, *Meriones meridianus* and *Meriones unguiculatus*, *Meriones meridianus* and *Cricetulus barabansis* were the highest, reached 0.992, 0.973 and 0.921, respectively, and closed to 1, which showed that their niche were complete overlap nearly. This result, also, showed that the three double-species above utilized resources unanimously as well as coexisted under different disturbance in desert habitats in spring. However, the niche overlap indices of *Salpingotus kozlovi* and *Citellus dauricus*, *Salpingotus kozlovi* and *Meriones unguiculatus*, *Salpingotus kozlovi* and *Cricetulus barabansis*, *Cricetulus evermanni* and *Cricetulus barabansis* were zero or closed to zero, meaning no overlap completely. It showed that the four double-species utilized habitat resources differently in spring, and had no competition each other.

In summer, the niche overlap indices of 12 double-species were the highest, and all of them were more than 0.9. They were *Citellus dauricus* and *Dipus sagitta* (0.927), *Allactaga sibirica* and *Meriones meridianus* (0.941), *Allactaga sibirica* and *Cricetulus barabansis* (0.921), *Dipus sagitta* and *Cardiocranius paradoxus* (0.948), *Dipus sagitta* and *Salpingotus kozlovi* (0.907), *Dipus sagitta* and *Mus musculus* (0.997), *Meriones meridianus* and *Cricetulus barabansis* (0.919), *Cricetulus evermanni* and *Cardiocranius paradoxus* (0.910), *Cricetulus evermanni* and *Salpingotus kozlovi* (0.942), *Cardiocranius paradoxus* and *Salpingotus kozlovi* (0.949), *Cardiocranius paradoxus* and *Mus musculus* (0.970), *Salpingotus kozlovi* and *Mus musculus* (0.920), respectively.

**Table 2** Spatial niche overlap index of desert rodents in different disturbance dimension

	<i>Citellus dauricus</i>	<i>Allactaga sibirica</i>	<i>Dipus sagitta</i>	<i>Meriones meridianus</i>	<i>Meriones unguiculatus</i>	<i>Cricetulus barabansis</i>	<i>Cricetulus evermanni</i>	<i>Phodopus roborovskii</i>	<i>Cardiocranius paradoxus</i>	<i>Salpingotus kozlovi</i>
<i>Allactaga sibirica</i>	0.472									
<i>Dipus sagitta</i>	0.768	0.503								
<i>Meriones meridianus</i>	0.555	0.889	0.327							
<i>Meriones unguiculatus</i>	0.341	0.471	0.037	0.789						
<i>Cricetulus barabansis</i>	0.276	0.849	0.181	0.953	0.793					
<i>Cricetulus evermanni</i>	0.603	0.702	0.897	0.843	0.318	0.401				
<i>Phodopus roborovskii</i>	0.962	0.527	0.774	0.513	0.221	0.239	0.567			
<i>Cardiocranius paradoxus</i>	0.449	0.431	0.904	0.189	0.000	0.042	0.925	0.434		
<i>Salpingotus kozlovi</i>	0.435	0.602	0.888	0.312	0.000	0.188	0.942	0.468	0.970	
<i>Mus musculus</i>	0.568	0.641	0.634	0.721	0.750	0.622	0.852	0.414	0.662	0.642

**Table 3** Niche overlap index of desert rodents in different disturbance dimension and season

	<i>Citellus dauricus</i>	<i>Allactaga sibirica</i>	<i>Dipus sagitta</i>	<i>Meriones meridianus</i>	<i>Meriones unguiculatus</i>	<i>Cricetulus barabansis</i>	<i>Cricetulus evermanni</i>	<i>Phodopus roborovskii</i>	<i>Cardiocranius paradoxus</i>	<i>Salpingotus kozlovi</i>
Spring										
<i>Allactaga sibirica</i>	0.440									
<i>Dipus sagitta</i>	0.451	0.416								
<i>Meriones meridianus</i>	0.669	0.692	0.217							
<i>Meriones unguiculatus</i>	0.612	0.514	0.133	0.973						
<i>Cricetulus barabansis</i>	0.353	0.751	0.047	0.921	0.879					
<i>Cricetulus evermanni</i>	0.515	0.351	0.992	0.221	0.152	0.009				
<i>Phodopus roborovskii</i>	0.851	0.667	0.750	0.505	0.359	0.270	0.765			
<i>Salpingotus kozlovi</i>	0.000	0.226	0.869	0.027	0.000	0.000	0.832	0.342		
<i>Mus musculus</i>	0.345	0.502	0.323	0.854	0.893	0.845	0.309	0.244		0.372
Summer										
<i>Allactaga sibirica</i>	0.382									
<i>Dipus sagitta</i>	0.927	0.371								
<i>Meriones meridianus</i>	0.572	0.941	0.451							
<i>Meriones unguiculatus</i>	0.202	0.568	0.024	0.659						
<i>Cricetulus barabansis</i>	0.218	0.921	0.095	0.919	0.777					
<i>Cricetulus evermanni</i>	0.753	0.706	0.869	0.680	0.330	0.460				
<i>Phodopus roborovskii</i>	0.863	0.302	0.650	0.564	0.131	0.248	0.402			
<i>Cardiocranius paradoxus</i>	0.772	0.368	0.948	0.351	0.000	0.054	0.910	0.378		
<i>Salpingotus kozlovi</i>	0.732	0.582	0.907	0.524	0.000	0.249	0.942	0.407	0.949	
<i>Mus musculus</i>	0.898	0.361	0.997	0.420	0.019	0.075	0.883	0.587	0.970	0.920
Autumn										
<i>Allactaga sibirica</i>	0.330									
<i>Dipus sagitta</i>	0.512	0.886								
<i>Meriones meridianus</i>	0.242	0.486	0.267							
<i>Meriones unguiculatus</i>	0.000	0.041	0.000	0.795						
<i>Cricetulus barabansis</i>	0.048	0.397	0.084	0.966	0.743					
<i>Cricetulus evermanni</i>	0.000	0.613	0.607	0.673	0.707	0.566				
<i>Phodopus roborovskii</i>	0.527	0.959	0.969	0.445	0.075	0.291	0.626			
<i>Salpingotus kozlovi</i>	0.000	0.826	0.859	0.157	0.000	0.057	0.707	0.810		
<i>Mus musculus</i>	0.000	0.406	0.384	0.781	0.895	0.690	0.948	0.429		0.447

The numbers of rodents that the niche overlaps indices were more than 0.9 increased more significantly than those in spring. On the one hand, in summer, plant was growing luxuriantly in Alashan Desert, and the richness of utilized resources of rodents increased; on the other hand, the unitary utilized resources limited diversity that rodents utilized resources, and caused the result of niche high overlap. And the niche overlap index of *Meriones unguiculatus* and *Salpingotus kozlovi* had never changed uniquely, and still equal zero.

In autumn, the numbers of rodents that the niche overlaps indices were greater than 0.9 were four double-species as follows: *Allactaga sibirica* and *Phodopus roborovskii* (0.959); *Dipus sagitta* and *Phodopus roborovskii* (0.969); *Meriones meridianus* and *Cricetulus barabansis* (0.966); *Cricetulus evermanni* and *Mus musculus* (0.948). The number was more reduction than that in summer. And the niche overlap indices of six double-species of rodents equaled 0, which were as follows: *Citellus dauricus* and *Meriones unguiculatus*, *Citellus dauricus* and *Cricetulus evermanni*, *Citellus dauricus* and *Salpingotus kozlovi*, *Citellus dauricus* and *Mus musculus*, *Meriones unguiculatus* and *Dipus sagitta*, *Meriones unguiculatus* and *Salpingotus kozlovi*. The number is three times more than in summer. The result showed that the niche and utilized resources of rodent emerged significant

differentiation. And the niche overlap index of *Meriones unguiculatus* and *Salpingotus kozlovi* had never changed uniquely, and still equaled zero.

In a word, the niche overlap indices of desert rodents appeared significant changes in three different seasons under different disturbance. However, there were two double-species of rodents had never changed. One was *Meriones meridianus* and *Cricetulus barabansis*, the niche overlap index of which was more than 0.9; another was *Meriones unguiculatus* and *Salpingotus kozlovi*, the niche overlap index of which was zero. It was suggested that the niche overlap and differentiation of desert rodent would change significantly with different seasons under different disturbance. The level of niche overlap was low, and that of niche differentiation was high in spring and autumn; on the contrary, the level of niche overlap was high, and that of niche differentiation was low in summer. With season changing, the niche overlap index of *Meriones meridianus* and *Cricetulus barabansis* was the highest throughout under four different disturbances. They utilized habitat resources to tend to be unanimous, and coexisted throughout in habitat. The niche differentiation of *Meriones unguiculatus* and *Salpingotus kozlovi* was the most distinct throughout. There was never competition each other for utilized resources.

## 4 Discussion

### 4.1 Competition and niche

Up to now, the competition of small mammals between species or inner species was observed hardly in the nature. Therefore, it was important to study the relationship between niche and competition that the redistribution of utilized resources between coexist species in different spatial and season was analyzed in depth. According to the studies on communities of desert rodents through two years in Alashan Desert, there was a significant difference between species of pairs at the extremely highest overlap indices and that of pairs at zero index in different spatial and seasons. The significant difference was analyzed using competition theory, regarded as intense competition to the species of niche overlap and differentiation changed, otherwise, weak competition. In general, intense competition was direct ratio with the niche overlap values from specific resources hierarchy (Putman and Wratten, 1994; Shang, 2002). However, in this study, specific resources hierarchy was never changed, the reason why the extremely highest niche overlap and differentiation presented changing on specific resources hierarchy in different seasons, was that the resources quantity, the level of rodent needed, and the difference of diet shape influencing rodent to feed probably determined the changing of rodent niche. Therefore, the niche shift appeared led niche separation of competition species and resources redistributed of coexistence species in different spatial conditions and seasons. Therefore, the utilized resource changed in different seasons was the important factor to influence interspecies competition and niche changing of rodent.

### 4.2 Utilized resources and niche

The niche breadth was the total resources of rodent utilized. The niche was more breadth and the specification level of the species more weak, namely the species even tended to a generalization species; on the contrary, tended to a specification species (Shang, 2002). In this paper, the niche breadth of rodent species had changed significantly under different spatial conditions and seasons (list in Tables 1 and 2). Therefore, through measuring the niche breadth indices of rodent species, it was made definite that the specification and generalization species of rodent were relative in certain ecological scale; there was substitution phenomenon each other in different spatial conditions and seasons. The change of characteristics could be suggested that rodent appeared in ecological response to environment change in a short time.

### 4.3 Ecological scale and niche

Ecological scale was an important basic concept of ecology which has attracted more and more attention (Ding, 2004).

It was needed on a correct ecological scale that any an ecological process was to be known, appraised and forecasted. How to select suitable ecological scale measuring niche under different disturbances was one of problems in connection with this paper. Ding (2004) pointed that ecological scale selected must be an optimum scale that was related biotic, abiotic and human process, however, the ecological scale selected often was completed by human's perception ability or limited technology and logic relation. In fact, the ecological scale selected was frequently limited by influence factors such as time, space, habitat, character and complexity of object studied. Therefore, the ecological scale had been divided into different extents by some scholars (Delcourt and Delcourt, 1983; Wu, 2000; Lv and Fu, 2001; Ding, 2004), then the extents were transformed by requisite scale and hierarchy according to different object and purpose studied, in the meantime, the transformed process must meet the standard of statistical analysis. In this paper, the four sites (an area of 10 hm<sup>2</sup>) were selected in every disturbance area, arranged as stagger, and interval of 1–2 km, which controlled area as about 10 km<sup>2</sup>. Therefore, the measured results of niche were different from those of small scale site (for example 1 hm<sup>2</sup>) and large scale site, but the results reflected the concrete character of an ecological process on certain scale. In large-scale desert region, the ecological significance of the scale, process and disturbance was still important problems that must be studied in depth.

**Acknowledgements** This paper was supported by the National Natural Science Foundation of China (Grant No. 30160019) and the Plan of Chun Hui from the Ministry of Education of China.

## References

- Abrams R (1980). Some comments on measuring niche overlap. *Ecology*, 61(1): 44–49
- Chen B, Zhou X M (1995). Analyses of niche breadths and overlap of several plant species in three *Kobresia* communities. *Acta Phytocologica Sinica*, 19(2): 158–169 (in Chinese)
- Chen L D, Fu B J (2000). Ecological significance, characteristics and types of disturbance. *Acta Ecologica Sinica*, 20(4): 581–586 (in Chinese)
- Delcourt H R, Delcourt P A (1983). Dynamic plant ecology: The spectrum of vegetation change in space and time. *Quaternary Science Review*, (1): 153–175
- Ding S Y (2004). *Ecology*. Beijing: Science Press, 11–24 (in Chinese)
- John A, James F (1990). *Statistical Ecology* (in Chinese, trans. Li Y Z, et al). Hohhot: Inner Mongolia University Press, 1990, 58–59
- Lin S Z, Huang S G, Hong W (2002). The characteristics of multi-dimension niche of dominant populations in Chinese fir and broad-leaved mixed forest. *Acta Ecologica Sinica*, 22(6): 962–968 (in Chinese)
- Lv Y H, Fu B J (2001). Ecological scale and scaling. *Acta Ecologica Sinica*, 21(12): 2,096–2,105 (in Chinese)
- Ma Y, Wang F G, Jin S K (1987). Glires (rodents and lagomorphs) of northern Xinjiang and their zoogeographical distribution. Beijing: Science Press, 91–199 (in Chinese)
- Peng S L (1989). A study of niche breadth of dominant populations in forestry community of Dinghushan. *Journal of Zhongshan University*, 13(3): 16–24 (in Chinese)

- Petraitis P S (1981). Algebraic and graphical relationship among niche breadth measures. *Ecology*, 62(3): 545–548
- Putman R J, Wratten S D (1994). Principles of Ecology (in Chinese, trans. Wang Y S, et al). Changchun: Jilin Science Technological Press, 1994, 133–164
- Shang Y C (1998). The theory of niche in the contemporary ecology. *Progress of Ecology*, 5(2): 772–784 (in Chinese)
- Shang Y C (2002). General Ecology. 2nd ed. Beijing: Beijing University Press, 284–295 (in Chinese)
- Sun R Y (2001). Principles of Animal Ecology. 3rd ed. Beijing: Beijing Normal University Press, 334–348 (in Chinese)
- Wang G (1984). On the measurement of niche overlap in plant communities. *Acta Phytoecologica et Geobotanica Sinica*, 8(4): 329–335 (in Chinese)
- Wang G, Zhao S L, Zhang P Y (1984). On the definition of niche and the improved formula for measuring niche overlap. *Acta Ecologica Sinica*, 4(4): 119–127 (in Chinese)
- Wu J G (2000). Landscape Ecology—Pattern, Process, Scale and Hierarchy. Beijing: Higher Education Press (in Chinese)
- Wu X D, Fu H P, Zhuang G H (2003). Geographical distribution and division of desert rodents in Alashan region of Inner Mongolia. *Chinese Journal of Zoology*, 38(2): 27–31 (in Chinese)
- Zhang L J, Yue M, Zhang Y D (2002a). Analysis on the niche of main plant species of oasis-desert ecotone in Fukang of Xinjiang. *Acta Ecologica Sinica*, 22(6): 969–972 (in Chinese)
- Zhang L J, Yue M, Zhao G F (2002b). Comparison of different measurements applied to oasis-desert ecotone. *Chinese Journal of Ecology*, 21(4): 71–75 (in Chinese)
- Zhao K T (1981). Rodents in Inner Mongolia. Hohhot: Inner Mongolia People's Press, 83–161 (in Chinese)
- Zhao T B, Zhang Z B, Li X M (2001). Population niche of *Rhombomys opimus* and *Meriones meridianus*. *Acta Theriologica Sinica*, 21(1): 76–79 (in Chinese)