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Rodent community patterns and their dynamics in the Chaihe Forest area in Zhangguangcai Mountains

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Abstract

To understand the dynamics of forest rodent community patterns on a time scale, this study conducted a survey in Daqing Forest Farm, Chaihe Forest Region from 2014 to 2016 and analyzed the rodent community pattern and its changes based on the results of Ruyong (1959). The results showed that the species and distribution of rodents varied in different habitats. The biomass of rodents increased and decreased in the plots with low and moderate disturbance, respectively, while it increased in the plots that were disturbed the most.

Keywords: Chaihe Forest Region; Rodents; Habitat; α diversity; β diversity.

Introduction

Rodent community ecology has played an important role in animal community ecology for a long time since the research by Zhong (Zhong et al. 1981). Since then, studies on rodent communities have gradually increased in China. Research (Han et al. 2004; Han et al. 2006) has shown that anthropogenic factors increase the community diversity index, climate, landform, soil structure and precipitation and determine the

types and diversity of rodent communities (Wu 2014). The rodent community scale undergoes a spatial organizational form of change along with the change in the plant community, particularly in different months; total food, precipitation and other factors in the natural environment change the diets of rodents, which affects the spread of plant seeds and the changes in food consumption, also resulting in a change in the rodent community structure (Askins et al. 1990; Herrert 1994; Vickery 1994; Ford et al. 1999; Helzer et al. 1999; Vieira 1999; Paul 2007).

In 1959, Ruyong conducted a detailed study on the community composition, seasonal variation and vertical distribution of rodents in the Chaihe forest region (Sun et al. 1962; Sun et al. 1962). In addition to natural impacts, such as climate change, human activities, such as tree cutting, artificial afforestation, agricultural planting, the construction of houses and roads, and the processing of domestic sewage, have also had a profound impact on the ecological environment of forests. Thus, they affect the survival and distribution of rodents. In this study, relevant sampling sites in the Chaihe forest region were studied again from 2014 to 2016 to analyze the forest rodent community pattern and its changes based on the historical research results.

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Place and method

Selection of study area and study site

The study area was selected in the Chaihe Forest Region (128°59′30″E − 129°54′30″E, 44°47′ 45″N − 45°37′30″N), southeast of Heilongjiang Province in the middle and lower reaches of Mudanjiang in the Zhangguangcai Mountains, which are

part of the east slope of the Changbai Mountain System. That is the same area where Sun conducted a rodent community survey in 1959. The Chenguang Forest Farm is located in the upper reaches of Sandaohezi. There are broad-leaved forests along the river, with a few coniferous trees, that comprise 10 % of the local area. There are a large number of coniferous and broad-leaved mixed forests in the mountains that comprises 85 % of the local area. Farmland comprises 4 %, and residential areas comprise 1 %. The Daqing Forest Farm is located in the middle reaches of Sandaohezi at the junction of coniferous and broad-leaved mixed forest belt and the broad-leaved forest belt. Mixed forest is the primary type of forest, comprising approximately 60 % of the total area. The broad-leaved forest comprises 30 %; the meadows comprise 9 %, and the residential area comprises 1 %. Erdaohezi is located at the junction of the Mudanjiang River and its tributaries Erdaohezi, which is in the broad-leaved forest belt. Broad-leaved forest is the primary forest type, comprising approximately 50 % of the total area. There are also some forests along the river, comprising 15 % of the total area, 30 % of the arable land and 5 % of the residential area. Based on the habitat characteristics of the sample plots and the habitat classification adopted by Sun (1959), four different types of typical habitats were selected, including coniferous and broad-leaved mixed forests, broad-leaved forests, forest meadows and forest land.

Rodent survey methods

To accurately compare the changes in the rodent community, this study was consistent with the method described by Sun (1959). From April to September of each year from 2014 to 2016, the clip-day method was used to study relative quantities. The trap was placed in a straight line with 25 clips per line. The study lasted for two days and nights. The capture results were checked each morning, and the study line was changed after two days and nights. The area was surveyed twice a month. Each type of sample set including approximately 2 to 3 line traps with lines that were 100 m long and spaced approximately 20 to 40 m apart.

Data analytical method

In this study, α diversity and β diversity were used to describe the diversity of the rodent populations. The species number of α diversity, Shannon-Weiner diversity, Simpson diversity and Pielou's evenness indices were used to describe the diversity of rodent populations at multiple time scales in the Chaihe forest region, and the dynamics of changes in diversity were compared. β-diversity is the range of community composition changes, which can be used to describe the diversity of animal communities at different spatial and temporal scales. In this study, the Cody, Sorenson similarity and Whittaker similarity indices were used to describe the temporal dynamics of rodent community turnover and similarity.

Results

Status of rodent communities

Morning light forest farm

The Morning light forest farm is less disturbed by humans and lacks a forest edge, The results for this habitat type are shown in Table 3-1. The dominant species in the mixed coniferous and broad-leaved forests was brown leewards, with a capture rate of 12.25 %, followed by the striped field mice (*Apodemus agrarius*), with a capture rate of 4.06 %. These rodents were only captured in the mixed coniferous and broad-leaved forests, with capture rates of 0.77 % and 0.09 %, respectively. The total percentage of rodents captured in the mixed coniferous and broad-leaved forests was 17.22 %, which was higher than that in the other two habitats. Only two species were captured in the broad-leaved forest, with a capture rate of 8.42 % and 3.26 %, respectively. Five species of rodents were captured in forest meadows, and the capture rate of brownbacked rodents was 7.63 %. This indicated that they were the dominant species in meadows. The capture rates of the striped field mice and hamsters were 2.05 % and 0.78 %, respectively. Striped field mice and rats (*Rattus norvegicus*), which are closely related to human activities, were also captured at rates of 0.57 % and 0.14 %, respectively. This may be owing to the fact that the meadows in this region are primarily distributed near human settlements along foothills.

Daqing Forest Farm

The habitat of Daqing Forest Farm is dominated by coniferous and broad-leaved mixed forests, accompanied by broad-leaved forests and a small number of meadows

and farmland. The survey results are shown in Table 3-1. The dominant species in the coniferous and broad-leaved mixed forests were brownbacks, with a capture rate of 9.28 %, followed by striped field mice, with a capture rate of 4.97 %. The capture rate of hamsters was 0.12 %. Only two species were captured in the broad-leaved forests, with a capture rate of 6.42 % and 7.21 %, respectively. Six species of rodents were captured in the forest meadow, with a capture rate of 9.06 %, which included the dominant species in the meadow. The capture rate of the striped field mice was 1.49 %, while that of *Cricetulus* was 0.23 %. That of the striped field mice was 1.49 % and 0.46 %, respectively. Black Lineage in Forest Farmland. The capture rate of rats was 8.53 %, which made them the dominant species; the capture rate of rats was 3.53 %, that of striped field mice was 1.76 %, and that of *Cricetulus* was 0.88 %.

Erdaohezi Forest Farm

A large area of farmland appeared in the Erdaohezi forest area owing to human disturbance, resulting in serious fragmentation of habitat. Broad-leaved forests composed of Mongolian oak (*Quercus mongolica*) were the primary forest land, and a small number of meadows and plantations were also found. The survey results are shown in Table 3-1. The dominant species of rodent in the broadleaf forests was striped field mice, and the capture rate was 15.35 %. The capture rate of the buff breasted rat (*R. flavipectus*) was 1.89 %, and that of the striped field mice was 1.79 %. Striped field mice are the dominant species in forest lands, with a capture rate of 14.39 %. The capture rate of hamsters, rats and Oriental voles was 7.19 %, 2.54 %

and 0.42 %, respectively. Six species of rodents were captured in forest meadows. The capture rate of *Cricetulus* was 13.07 %; that of the striped field mice was 7.05 %; that of the striped mice was 3.53 %; that of reed voles (*Microtus fortis*) was 1.87 %; that of rats was 1.24 %, and that of buff breasted rats was 0.21 %.

Species and distribution of rodents

The distribution of various rodents in different habitats differed as shown in Table 3 – 2 and Fig. 3 – 1. The dominant species in the mixed coniferous and broad-leaved forests were brown dorsal hornets and striped field mice, comprising 67.76 % and 28.03 % of the total captured species, respectively. The broad-leaved forest was also dominated by brown dorsal horns and striped field mice, comprising 43.19 % and 50.00 % of the total capture, respectively. However, there were more striped field mice than the XX, but there were more striped field mice than brown dorsal horns. There was a relatively large distribution of rats in the forest meadow, which was composed of 46.40 % of brown dorsal horns, 18.86 % of hamsters, 14.39 % of striped field mice and 13.40 % of striped field mice. Striped field mice, hamsters and rats comprised 58.41 %, 24.34 % and 12.83 %, respectively. Few Oriental voles were caught in the survey. They were only distributed in meadows and farmland. Northern red-backed voles (*Myodes rutilus*) were only captured in the coniferous and broad-leaved mixed forests of Chenguang Forest Farm at higher altitudes, and none of these species were captured in other plots. Rats only appeared in plots that were near residential areas.

Overall, the capture rate of rodents in the coniferous and broad-leaved mixed forests was the highest in forest areas that were far away from farmland and villages, and crops in the farmland also attracted a large number of rodents. In addition, rats and striped field mice were also distributed in parallel with human habitation. Therefore, the farmland also had a high capture rate.

Rodent community distribution dynamics

As shown in Table 3-3 and Figure 3-2, the capture rate of palm-back voles in the Chenguang Forest Farm in 1959 was 34.72 %, comprising 75.31 % of the total. Thus, this was the dominant species in the Chenguang Forest Farm. However, the capture rate of palm dorsal voles in the Daqing forest farm decreased to 10.68 %, comprising 37.34 % of the total. In the two rivers, the capture rate of brown leewards was only 0.10 %, comprising 0.65 % of the total. In 2014-2016, the capture rate of the palm back voles was 9.76 %, comprising 71.98 % of the total. Thus, it was still the dominant species in the Chenguang Forest Farm. In the Daqing Forest Farm, the capture rate of the brown forest fell to 7.75 %, comprising 53.90 % of the total. In the second river, no palm back voles were captured. From 1959 to 2016, the proportion of brown forest in the morning light forest increased by 3.33 %, with little change, while the proportion in Daqing Forest Farm increased by 16.56 %. The number of brownback voles progressively decreased with elevation, and they are more suitable for cold and humid coniferous and broad-leaved mixed forests. In contrast, they are less abundant in lower-elevation broad-leaved forests. After human disturbance, the

capture rate of brownback voles decreased significantly in all three sampling sites, and no brownback voles were captured in two channels.

In 1959, the capture rate of striped field mice was 4.44 %, comprising 9.62 % of the total. The capture rate of striped field mice in the Daqing Forest Farm was 11.72 %, comprising 40.98 % of the total. This was the largest proportion. The capture rate in Erdaohezi was 4.18 %, comprising 26.45 % of the total. The capture rate of striped field mice in the Chenguang Forest Farm from 2014 to 2016 was 3.29 %, comprising 24.25 % of the total. The capture rate was 4.87 % in the Daqing Forest farm, comprising 34.98 % of the total. In Erdaohezi, the capture rate of striped field mice was 7.61 %, comprising 33.61 % of the total. This was the largest proportion. The distribution of numbers of Korean field mice (*A. peninsulae*) did not increase or decrease with altitude. From 1959 to 2016, the capture rates of Korean field mice in the Chenguang and Daqing Forest Farms decreased by 1.15 % and 6.85 %, respectively, while the capture rate in Erdaohezi increased by 3.53 %. The Korean field mice were adaptable to broad-leaved forests than the brownback voles.

Striped field mice are typical farm rodents and have a large population in Erdaohezi. In 1959, the capture rate of striped field mice in Erdaohezi was 7.43 %, comprising 47.10 % of the total, making it the dominant species. The capture rate in Erdaohezi in 2014-2016 was 7.14 %, or 31.55 % of the total. The capture rate and proportion of striped field mice in the Chenguang Forest Farm were 0.39 % and 0.14 %, respectively. In contrast, the capture rate and proportion of striped field mice in the Daqing Forest Farm were 1.84 % and 0.93 %, respectively. The capture rate of

striped field mice gradually decreased in parallel as the intensity of human activities grew stronger, and the altitude decreased. From 1959 to 2016, the population number of striped field mice remained basically the same, which was primarily related to the artificial farmland habitat.

The population of mice changed substantially. The capture rates in the Chenguang Forest Farm in 1959 and 2014-2016 were 3.18 % and 0.12 %, respectively. In 1959, the capture rate in the Daqing Forest Farm was 1.92 %, while no rats were captured in that survey. The capture rates in Erdaohezi in 1959 and 2014-2016 were 0.10 % and 0.89 %, respectively. The capture rate was low but had increased.

In 1959 and 2014 – 2016, the capture rates of redback forest at a high altitude in the Chenguang Forest Farm were 2.22 % and 0.03 %, respectively. In 1959, the capture rate in the Daqing Forest Farm was 1.12 %, while none were captured in this survey. In Erdaohezi, no red leewards were captured, which was consistent with the habit of red leewards adapting to cold high altitude coniferous and broad-leaved mixed forests.

The capture rates of hamsters in the Chenguang and Daqing Forest Farms were very low in 1959 and 2014-2016, while the capture rate in Erdaohezi increased significantly from 0.81 % to 5.32 %, respectively, which was related to the increase in local farmland. The hamsters were mostly captured in the agroforestry ecotone.

There were fewer Oriental voles in the Daqing and Erdaohezi Forest Farms, and they were not captured in the Chenguang forest farm with coniferous and broad-leaved mixed forests at higher altitudes. Since rats are atypical forest rodents

and are associated with human habitation, only a small number of them were captured near the settlements.

Chenguang forest farm is located at the end of the forest road Bachen line, making it the least disturbed by human activities, followed by the Daqing Forest farm. Both places have a good forest ecosystem. Erdaohezi is the most seriously disturbed by human activities, and the broad-leaved forest + farmland ecosystem is the primary ecosystem. The biomass of rodents in the forest ecosystem of Chenguang Forest Farm and Daqing Forest Farm decreased significantly, while the rodents in the broad-leaved forest + farmland ecosystems of Erdaohezi were highly adaptable, and the biomass of rodents increased significantly.

Changes of α diversity in the rodent community

The Shannon-Wiener diversity index indicated that the diversity of rodents in the Chenguang Forest Farm decreased, and this index decreased from 1.312 to 1.093. Combined with the survey results of rodents, it was apparent that the decrease in diversity index was caused by a decrease in evenness because the number of species did not change. The main reason was the significant increase in the proportion of striped field mice, which increased from 9.62 % to 24.25 %. The diversity of rodents also decreased in the Daqing Forest Farm. The Shannon-Wiener index decreased from 1.991 to 1.531, which was owing to the decrease in species number and evenness. Combined with the results of survey on rodents, the proportion of dominant species increased from 37.34 % to 53.90 %, which was the main reason for the decrease in

evenness. The diversity of rodents in the Erdaohe River increased slightly, and the Shannon-Wiener index increased from 1.998 to 2.075. The results of survey of rodents indicated that although the number of species decreased by one species, the evenness increased. The proportion of striped field mice decreased significantly from 47.10 % to 31.55 %, which combined with the significant increase in the proportion of *Cricetulus* from 5.16 % to 23.51 %, were the primary reasons for the increase of evenness. The Simpson diversity index indicated that the rodent diversity in Chenguang Forest Farm increased slightly, and the Simpson index increased from 0.416 to 0.425, which differed slightly from the results of Shannon-Wiener index. The diversity of rodents in the Daqing Forest Farm decreased, and the Simpson index decreased from 0.681 to 0.582. In contrast, the diversity of rodents in Erdaohezi increased, and the Simpson index increased from 0.685 to 0.728. When the diversity changes, the combined effects of species richness and evenness indicate that the effects of human disturbance on the diversity of small rodents vary. The diversity of rodents in the Daqing Forest Farm decreased, and that in the Erdaohe River increased. The diversity of rodents in Chenguang Forest Farm differed in the Shannon-Wiener and Simpson indices as shown in Table 3 – 4.

Changes in the β diversity of rodent communities

The Cody index can describe the change in rodent species. The Cody index of rodents before and after the Chenguang forest farm with the least amount of human disturbance was 0, indicating that there was no change in the composition of rodent

species on this farm from 1959 to 2016. The Cody index of the Daqing forest farm that had been moderately disturbed was 1.50, which was the highest in the three different disturbance plots. Erdaohezi had been interfered with the most strongly, and its Cody index was 0.50. This indicates that the replacement status of rodent species is lower than that of the Daqing forest farm. The Sorenson similarity index of 1.0 for the Chenguang forest farm indicated that it had the least amount of disturbance, and the species composition of rodents did not change. The Sorenson similarity index of the Daqing Forest Farm was 0.769, and the group of rodent species substantially changed. According to the survey results, five species did not change; two original species disappeared, and one new species was added. The Sorenson similarity index of Erdaohezi was 0.923, and the composition of rodent species was highly similar. The survey results indicate that one species was reduced, and no species increased. The Whittaker similarity index was 0.840 for the Chenguang Forest Farm. The composition of rodents changed to some extent, but the similarity remained high. The Whittaker similarity index of the Daqing Forest Farm was 0.821, and the changes in the composition proportion of rodents were slightly larger than those of the Chenguang Forest Farm.

Discussion

Among the theories about the impact of interference on biodiversity, the moderate interference hypothesis is an important theory, which is supported by many studies (Collins et al. 1995; Morris et al. 2006; Hiddink et al. 2007). A comparison of the

diversity of small rodents from 1959 to 2016 using the Shannon-Wiener index showed that the diversity of rodents in Chenguang Forest Farm and Daqing Forest Farm that were less disturbed decreased, and the diversity of rodents in Erdaohezi that had a greater level of disturbance increased slightly. The Simpson diversity index indicated that the rodent diversity in Chenguang Forest Farm and Erdaohe Forest Farm increased, while that in Daqing Forest Farm decreased. The Cody index of rodents in the Chenguang Forest Farm before and after human disturbance was 0, indicating that the species composition of rodents in Chenguang Forest Farm did not change before and after human disturbance. The rodents in Daqing Forest Farm obviously had species replaced, and the Cody index was 1.50. This value was the highest among the three plots with different degrees of disturbance. The replacement status of rodent species in Erdaohezi was lower than that in the Daqing Forest Farm. From 1959 to 2016, rodents in the Chaihe forest area were not subjected to natural and human disturbance according to a certain frequency or a single factor. The characteristics of disturbance were continuous and comprehensive. The disturbance not only affected rodents themselves but also had an important impact on their habitats.

Conclusions

The distribution of various rodents in different habitats in the Chaihe forest area varied. Compared with the survey results in 1959, the richness of rodents in coniferous and broad-leaved mixed forest and broad-leaved forest had decreased significantly, while the richness of rodents in swampland increased. The diversity of

rodents in the coniferous and broad-leaved mixed forests decreased significantly. However, the diversity of rodents in the broad-leaved forests did not change significantly, and the diversity of rodents in the swamp increased. The uniformity of coniferous and broad-leaved mixed forest, broad-leaved forest and swampland increased. The richness of different habitats was meadow > field > coniferous and broad-leaved mixed forests > broad-leaved forest. The evenness index of rodents in different habitats was meadow > broad-leaved forest > field > mixed forest. The biomass of rodents both grew and declined. The biomass of the plots at lower and medium amounts of disturbance decreased, while that of the plots that were disturbed the most strongly increased.

Acknowledgements

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Figure Legends

Fig. 1. The capture rate of rodents in different habitats

Fig. 2. The capture rate of rodents before and after different degrees of disturbance

Figure 1

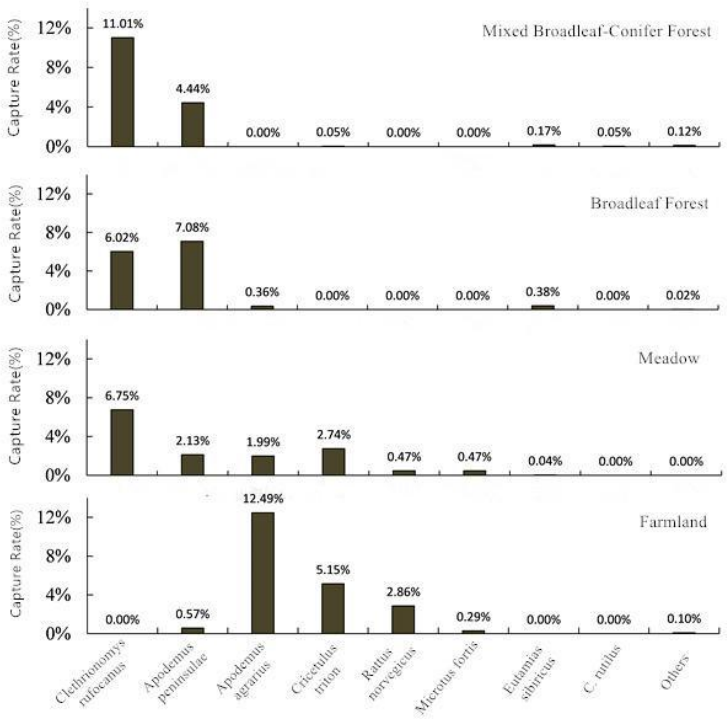

Figure 2

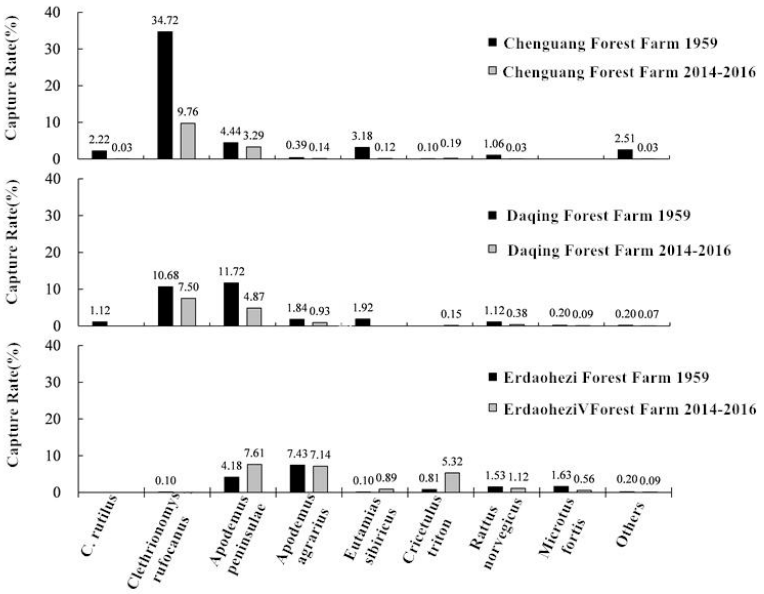

Table 1. The composition of rodents in different habitats after human disturbance

Sampling Site	Habitats	Number of Traps	Capture Rate (%)									Total Capture Rate (%)
			Microtus fortis	*Eutamias sibiricus*	*Cricetulus triton*	*Rattus norvegicus*	*Clethrionomys rufocanus*	*Clethrionomys rutilus*	*Apodemus peninsulae*	*Apodemus agrarius*	Others	
Chengguang Forest Farm	Mixed Broadleaf-Conifer Forest	2,342	–	0.77	–	–	12.25	0.09	4.06	–	0.09	17.22
	Broadleaf Forest	2,114	–	–	–	–	8.42	–	3.26	–	–	11.68
	Meadow	1,415	–	–	0.78	0.14	7.63	–	2.05	0.57	–	11.17
Daqing Forest Farm	Mixed Broadleaf-Conifer Forest	1,671	–	–	0.12	–	9.28	–	4.97	–	0.18	14.54
	Broadleaf Forest	1,636	–	–	–	–	6.42	–	7.21	–	–	13.63
	Meadow	872	0.46	–	0.23	0.57	9.06	–	1.49	1.49	–	13.30
	Farmland	340	–	–	0.88	3.53	–	–	1.76	8.53	–	14.71
Erdaohezi Forest Farm	Broadleaf Forest	951	–	1.89	–	–	–	–	15.35	1.79	0.11	19.35
	Farmland	709	0.42	–	7.19	2.54	–	–	–	14.39	0.14	24.68
	Meadow	482	1.87	0.21	13.07	1.24	–	–	3.53	7.05	–	26.76

Table 2. The number of rodents captured in different habitats

	Species	Habitats			
		Mixed Broadleaf-Conifer Forest	Broadleaf Forest	Meadow	Farmland
Capture number	*Clethrionomys rufocanus*	442	283	187	–
	Apodemus peninsulae	178	333	59	6
	Apodemus agrarius	–	17	55	131
	ton	2	–	76	54
	Rattus norvegicus	–	–	13	30
	Microtus fortis	–	–	13	3
	Eutamias sibiricus	7	18	1	–
	C. rutilus	2	-	–	–
	Others	5	1	–	1

Table 3. The capture number of rodents in 1959 and 2014～2016

	Chenguang Forest Farm		Daqing Forest Farm		Erdaohezi Forest Farm	
Year	1959*	2014-2016	1959*	2014-2016	1959*	2014-2016
C. rutilus	23	2	28	–	–	–
Clethrionomys rufocanus	360	573	267	339	1	–
Apodemus peninsulae	46	193	293	220	41	163
Apodemus agrarius	4	8	46	42	73	153
Eutamias sibiricus	33	7	48	–	1	19
Rattus norvegicus	1	11	–	7	8	114
Cricetulus triton	11	2	28	17	15	24
Microtus fortis	–		5	4	16	12
Total	478	796	715	629	155	485

*According to Sun Ruyong (1962).

Table 4. Comparison of the rodent α diversity in 1959 and 2014～2016

	Chenguang Forest Farm		Daqing Forest Farm		Erdaohezi Forest Farm	
Year	1959*	2014-2016	1959*	2014-2016	1959*	2014-2016
Number of Species	7	7	7	6	7	6
Index of Shannon-Wiener	1.312	1.093	1.991	1.531	1.998	2.075
Index of Simpson	0.416	0.423	0.681	0.582	0.685	0.728
Index of Pielou's	0.467	0.389	0.709	0.592	0.712	0.803