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Species composition of small mammal and abundance in natural and rehabilitated saxaul forest at the Gunii khooloi, Khanbogd soum

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Abstract

The research was conducted in the Southern Mongolia (107˚4052'E, 43˚4187'N) in 2016, 2017 and 2020. We collected small mammal data from two plots located in Gunii khooloi (GKh) borefield areas of Khanbogd soum. The number of sampling plots was determined in consideration of comparison of vegetation in the rehabilitated and natural area. Capture-mark-recapture method, using Sherman traps, is being used for this study. 66 individuals of 4 species of 4 genera were identified from rehabilitation plot. In comparison, a total of 122 small mammals belonging to 5 species of 5 genera were captured and identified from the natural plot. P. roborovskii, M. meridianus, and D. sagitta were the dominant species in both rehabilitation plot and natural plot in GKh. Species diversity, richness, and evenness indices of small mammal at rehabilitation plot were lower than at the natural plot in 2016 and 2017, while species diversity, richness, and evenness at rehabilitation plot were higher than at natural plot in 2020. There were no significant differences in the abundance between the rehabilitation plot and natural plot. The study showed that small mammal abundance (on average 71.2 individuals/ha) in the natural plot was higher than small mammal abundance (56.1 individual/ha) in the rehabilitation plot in GKh borefield area. Preliminary study results are showing that there is a rapid colonization of the rehabilitation areas; however, the natural saxaul forest has higher density six years after rehabilitation plantings were completed, also species diversity, species richness, and species evenness in rehabilitation plot became same to the natural saxaul forest. Most rehabilitation and closure monitoring is focusses on vegetation monitoring; the present study shows the importance of other types of monitoring to assess the function of the rehabilitated ecosystem. This study will be continued to get more precise evaluation of small mammals' succession in rehabilitated area. This study illustrates that other ecological end-points should be included in the monitoring of rehabilitation areas.

Keywords: *abundance, ecological succession, small mammal, saxaul rehabilitation*

1 Introduction

Small mammals are the goal of forest management to preserve ecological values. Small mammals affect the structure of forest vegetation through seed consumption and distribution (Gashwiler 1970).

Small mammal communities in southern Gobi include five relatively common species: Desert hamster (*Phodopus roborovskii*), Gobi jerboa (*Allactaga bullata*), Balikun jerboa (*Allactaga balikunica*), Midday gerbil (*Meriones meridianus*), and Northern three-toed jerboa (*Dipus sagitta*). *P. roborovskii* are small (14 - 20 g) omnivorous, nocturnal, murid rodents common throughout south and southwestern Mongolia and found frequently in sandy habitats in desert and semi-desert. *A. bullata* are medium sized (70 - 90 g) nocturnal, jerboa that inhabit shrubby arid desert and semi desert with gravelly soils. *A. balikunica* are medium sized (65 - 80 g), omnivorous, nocturnal. They inhabit arid desert and semi desert with clay-based soils. *M. meridianus* are relatively small gerbil (30 - 60 g) omnivorous, active day and night. They are true representative of the Gobi and favour small hills, lowlands with sandy soil. *D. sagitta* are medium sized (46 - 128 g) nocturnal jerboa occur regularly in sandy and gravelly areas (Batsaikhan et al. 2014).

The Oyu Tolgoi (OT) mine is located in the Gobi Desert, where bushes such as saxaul (*Haloxylon ammodendron*) provide important habitat for many species of small mammals, reptiles and birds. OT obtains raw water from the Gunii Khooloi (GKh) ground water deposit, which required the construction of approximately 80 km of buried pipeline for industrial use. A portion of the pipeline crossed an area of saxaul forest (Figure 1a). Following completion of the pipeline construction, the pipeline right-of-way was rehabilitated (Figure 1b). This included approximately 50 ha of saxaul rehabilitation and an additional 6 ha of saxaul offset planting. The survival and growth of saxaul has been closely monitored as these are traditional endpoints of rehabilitation monitoring. OT has also been assessing the ecological succession of rehabilitation areas by monitoring the succession of small mammals inhabiting the rehabilitated area. Our study objectives were: 1) to determine species composition of small mammal, 2) to estimate species abundance in the natural saxaul forest (control plot) and rehabilitation plot, and 3) assess changes over time.

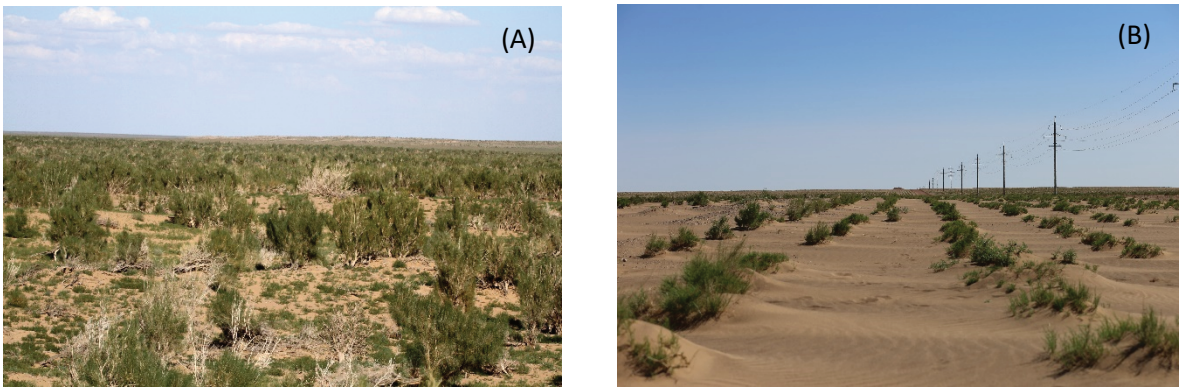

Figure 1 Natural plot (A) and rehabilitation plot (B) of studied small mammal community

2 Methodology

2.1 Study Area

The research was conducted in the southern Mongolia (107˚4052'E, 43˚4187'N), some 30 km northeast of Khanbogd Soum center and 650 km south of Ulaanbaatar (Figure 2). The research area has obvious seasonal changes with short spring and autumn, hot summer and cold winter. The area has an arid climate, with a temperature range of -31.1°C in winter and +42.2°C in summer. Average annual precipitation is 97mm with approximately 70% of this falling in the June to September period (Oyu Tolgoi 2015).

The vegetation types included in research area are desert semi desert and true desert. The desert is mainly distributed in Alashan league and mainly consists of halo-shrubs, semishrubs, small shrubs and small semi-shrubs. The main dominant species are *Calligonum mongolicum*, *Nitraria sibirica*, *Zygophyllum xanthoxylum*, and *Haloxylon ammodendron* (Figure 1a).

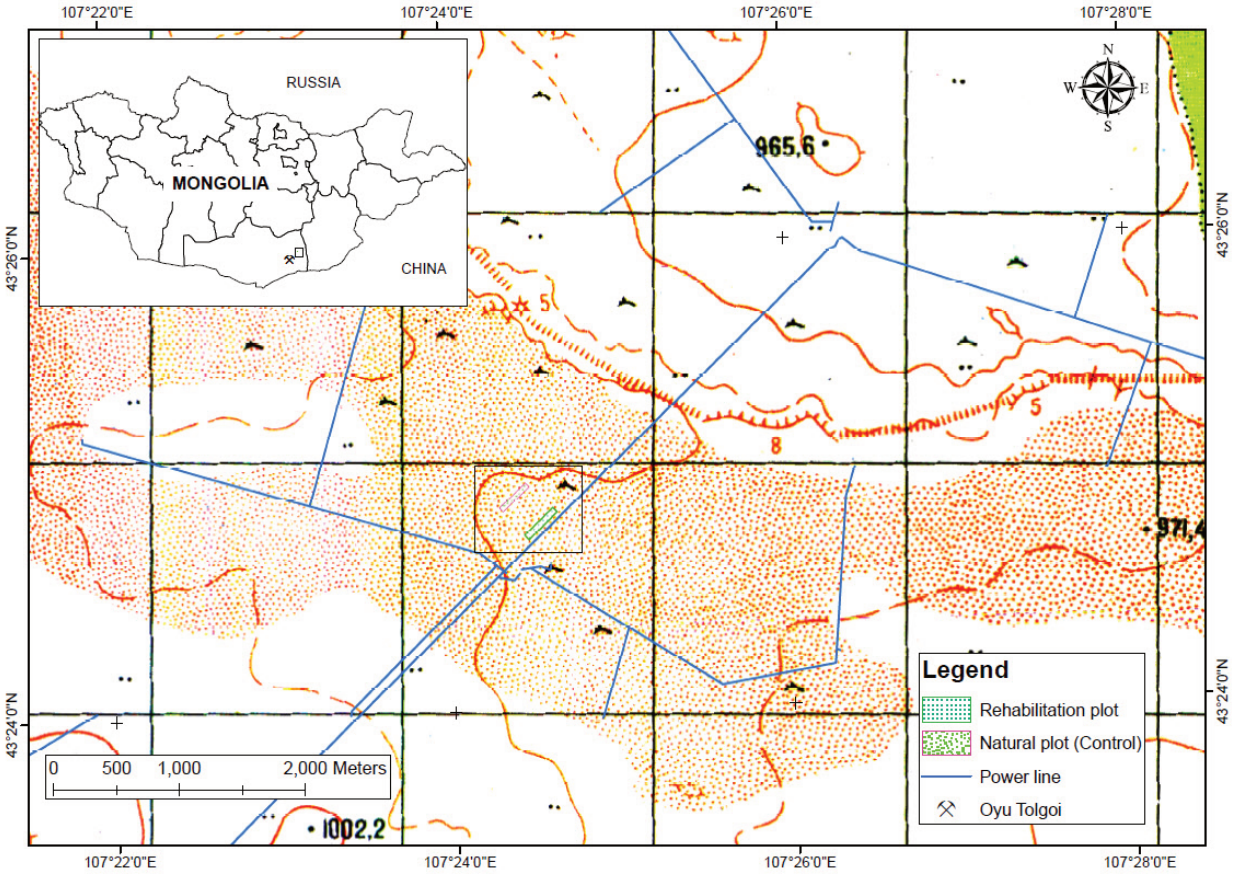

Figure 2 Sketch map of research plots of investigated small mammal community in the Khanbogd soum of southern Mongolia

2.2 Small mammal trapping

This study was conducted in 2016, 2017 and 2020 when we surveyed small mammals at two plots located in the Gunii khooloi (GKh) borefield area of Khanbogd soum, southern Mongolia. One plot was in an area of natural, undisturbed, saxaul forest while the second was in an adjacent area of saxaul rehabilitated following installation of the GKh pipeline (Figure 2). The construction of the GKh pipeline was completed in 2012 and rehabilitation areas were planted with saxaul in 2013. The sampling done in 2016, 2017 and 2020 represent years 3, 4 and 7 after planting of rehabilitation areas. Two transect lines were set in each sampling plot, with transect lines 10 m apart (Figure 3). A total of 25 folding Sherman live traps (10.2 cm × 11.4 cm × 38.1 cm) were placed at 10 m intervals along each transect (250 m transects length, Figure 3) and baited using a mixture of rice, grains and peanut butter.

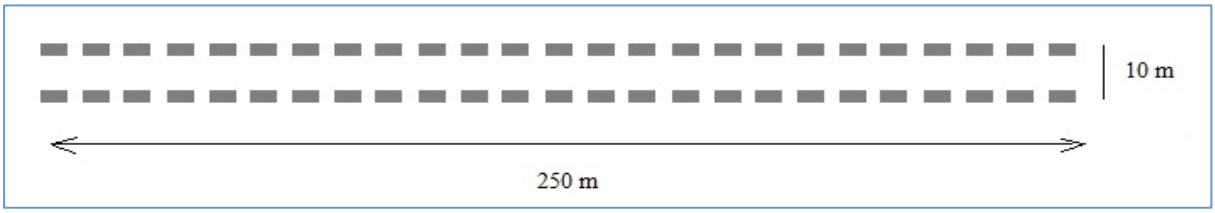

Figure 3 Schematic of the installation pattern of Sherman live trap

Surveys occurred during three sessions, 25 to 27 September 2016, 5 to 8 August 2017, and 14 to 16 August 2020, during which time traps were set and checked in the morning of each 24-hour period. All individuals captured were processed at the capture site, where they identified following Batsaikhan et al. (2014), measured, weighed and photographed, reproductive characteristics assessed by external examination, and then released on-site.

3 Data Analysis

Four approaches were used to compare the small mammal communities in undisturbed and rehabilitated sites, as each reflects a different aspect of community composition. (1) Relative abundance: defined as the total number of captured animals/total number of snap-traps × 100 (Jiang et al. 2011). (2) Shannon's index of species richness: this index does not change when the number and proportions of species remain constant and therefore changes (especially decreases) in its value are indicative of disturbances in the structure of dominance and disappearance of certain species from the community. The Shannon index was calculated as following Shannon and Weaver (1949):

$$Da = (s - 1)/\ln(N) \quad (1)$$

where:

S = is the total number of species that both Community A and Community B have; N is the total number of individuals in survey area.

The community diversity was analyzed using the Shannon-Wiener diversity index and Pielou evenness index (Pielou et al. 1966):

$$H = -\sum P_i \ ln \ P_i \quad (2)$$

where:

H = Shannon-Wiener's diversity index; and

Pi = the relative abundance ratio of species *i* to total species in one community, being;

$$J = H/Hmax \quad (3)$$

where:

J = Pielou evenness index; and

Hmax = the theoretic maximum value of Shannon-Wiener's diversity index.

Otis et al. (1978) provides a series of closed population capture-mark-recapture models. All models (e.g., M0, Mt, Mh Chao, Mh Poisson2, Mh Darroch, Mh Gamma3.5, Mth Chao, Mth Poisson2, Mth Darroch, Mth Gamma3.5, Mb and Mbh) were run to estimate abundance of each species at the study plots and selected best one loglinear model from them based on the Akaike Information Criterion (AIC) using the 'Rcapture' library in R (R Development Core Team, 2008). Closed function uses the numbers of units captured i times, for i=1,…,t (vector of size t).

Capture-recapture parameters contain N, the estimated population size, and p or p1 to pt defined as follows for the different models:

- M0: the capture probability at any capture occasion;
- Mt: the capture probabilities for each capture occasion;
- Mh: models: the average probability of capture;
- Mth: models: the average probabilities of capture for each occasion;
- Mb and Mbh: the probability of first capture at any capture occasion.

Models Mb and Mbh also contains "c," the recapture probability at any capture occasion (Baillargeon and Rivest 2007).

4 Result

During the 2016, 2017 and 2020 small mammal trapping at the GKh, a total of 500 traps, with a total of 188 individuals belonged to six species captured in the two research plots. The number of species at the undisturbed plot increased from 3 to 4 over the survey period, whereas at the rehabilitated plot increased from 1 to 4 species over the same period (Figure 4).

Species composition and abundance differed between plots, with dominant species being *P. roborovskii, M. meridianus*, and *D. sagitta* in both rehabilitated and natural saxaul plots. There were two species (*A. balikunica* and *S. andrewsi*) in the undisturbed plot that were not recorded in the rehabilitation plot.

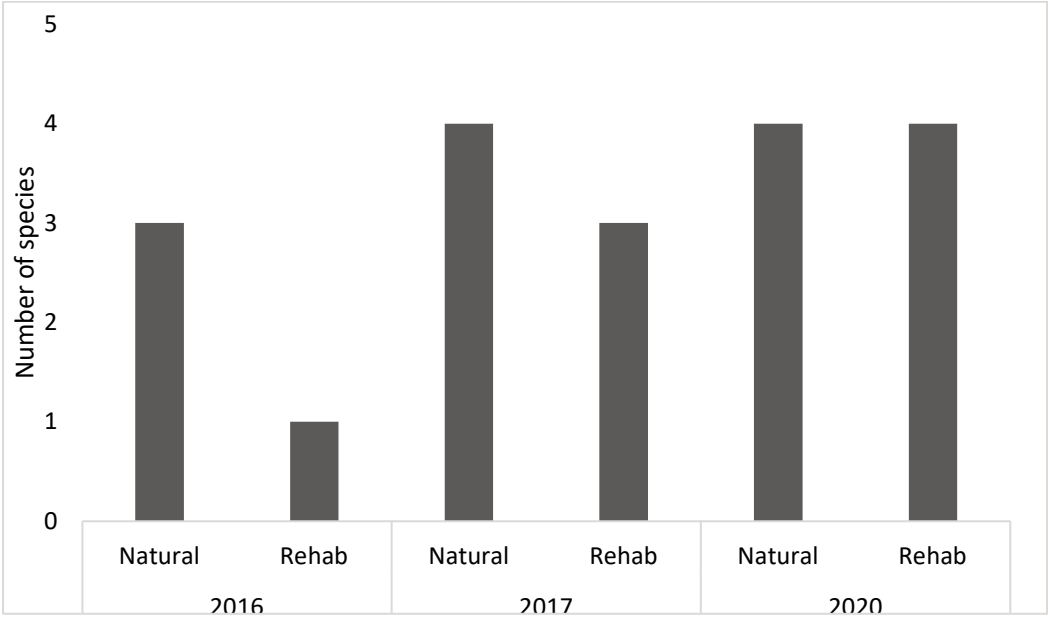

Figure 4 Number of species in rehabilitated and natural plots

In natural and rehabilitation plots, we captured three species and 43 individuals in 2016. The dominant species were *M. meridianus* and *P. roborovskii,* which was similar to the result of the OT research in 2020 (Oyu Tolgoi 2020) that showed dominant species were *M. meridianus, P. roborovskii,* and *A. balikunica* (Figure 5). Natural plot showed the three species and 29 individuals and its species diversity, species richness, and species evenness were the highest 0.81, 0.59, and 0.72, respectively. In rehabilitation plot only one species and 14 individuals were trapped. It was not possible to calculate species richness, and species evenness due to the single species and small number of individuals captured. The results indicate that the natural plot is better place for diverse small mammals to be inhabited than rehabilitation plot because it had various plant species such as tall saxaul forest.

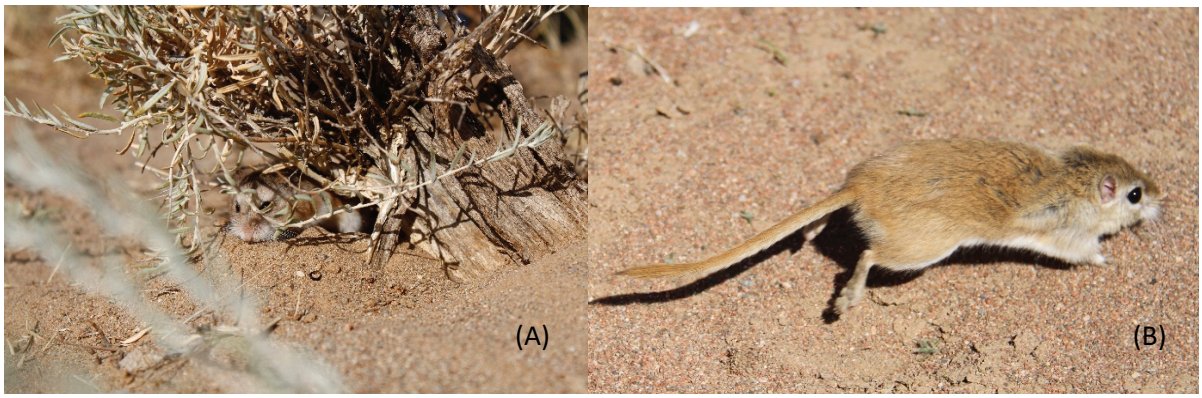

Figure 5 P.roborovskii (A) and M.meridianus (B) were dominant species in study plots

In 2017, research in natural and rehabilitation plots caught five species and 80 individuals, which was an increase from 2016 results. The dominant species were *M. meridianus, P. roborovskii,* and *D. sagitta.* These are common species in variety of habitats within this ecosystem (Oyu Tolgoi 2019). Four species and 51 individuals, were trapped in the natural plot and three species were in higher abundance than in 2016. Species diversity, species richness, and species evenness were 1.02, 0.76, and 0.72, respectively. Three species and 29 individuals were captured in the rehabilitation plot in 2017, which was also increase from the 2016 sampling results. Species diversity, species richness, and species evenness at the rehabilitation plots were 0.74, 0.60, and 0.67.

There were four species and 42 individuals in the natural plot captured in 2020 and species diversity, species richness, and species evenness were 0.92, 0.80, and 0.66. Whereas, four species and 24 individuals were trapped in the rehabilitation plot and species diversity, species richness, and species evenness were 1.01, 0.94, and 0.72 respectively (Figure 6).

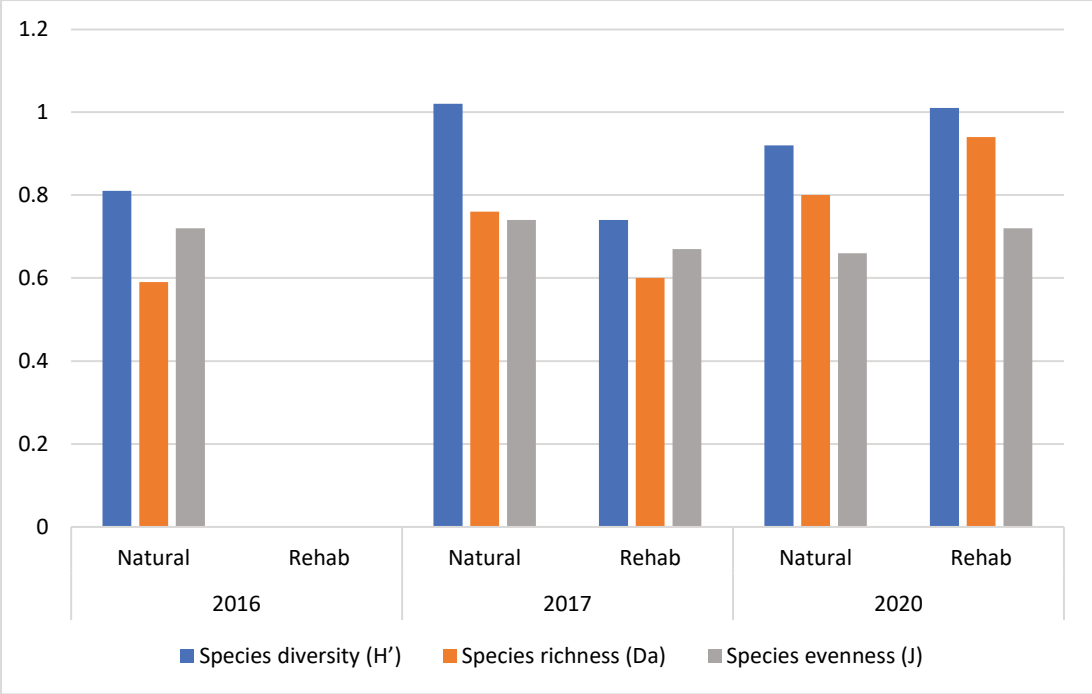

Figure 6 Diversity indices of small mammal communities in rehabilitated and natural saxaul plots

A high portion of *P. roborovskii* in rehabilitation plot led to higher species diversity. *P. roborovskii* was trapped consistently at the all plots in 2016, 2017, and 2020. There were an approximately 2X increase in the total number of individuals that captured in the control and rehabilitation plots from 2016 to 2017 and 2020 (Table 1).

Table 1 Summary result of small mammal research in natural and rehabilitation plots in Gunii khooloi

Species	2016		2017		2020		Total	Ratio (%)	Relative abundance
	Natural	Rehab	Natural	Rehab	Natural	Rehab			
Allactaga balikunica			1				1	0.53	0.2
Dipus sagitta	1		7	4	15	5	32	17.02	6.4
Meriones meridianus	14		29		24	3	70	37.23	14
Phodopus roborovskii	14	14	14	21	2	15	80	42.55	16
Allocricetulus curtatus					1	1	2	1.06	0.4
Stylodipus andrewsi				3			3	1.59	0.6
Number of species	3	1	4	3	4	4			
Number of individuals	29	14	51	28	42	24			
Species diversity (H')	0.81	NA	1.02	0.74	0.92	1.01			
Species richness (Da)	0.59	NA	0.76	0.6	0.8	0.94			
Species evenness (J)	0.72	NA	0.74	0.67	0.66	0.72			

Rehab: Rehabilitation plot, NA: Not Applicable

In most cases, the best-fit model selected by AIC for three species (*M. meridianus, P. roborovskii, D. sagitta*) was the null model M0, which assumes no variation among capture probabilities; the time model Mt, which assumes variations over time; and the behavior plus heterogeneity model Mbh, which assumes variation in behavior plus heterogeneity of capture probabilities. Among all species monitored, estimated abundances were generally higher in 2017 and 2020 than 2016. These differences were most apparent for *P. roborovskii*, *M. meridianus*, and *D. sagitta*. In 2016, only one species (*P. roborovskii* [45.2±10 individual/ha]) was captured from rehabilitation plot and three species (*P. roborovskii* [44.4±15.2 individual/ha], *M. meridianus* [29.2±2.8 individual/ha], and *S. andrewsi* [1 individual]) were captured in the control plot. In 2017, three species (*P. roborovskii* [70.8±15.2 individual/ha], *D. sagitta* [4 individuals], and *S. andrewsi* [3 individuals]) were captured from rehabilitation plot and four species (*M .meridianus* [114.4±24 individual/ha], *P. roborovskii* [116.4±64.4], *A. balikunica* [1 individual] and *D. sagitta* [25.2±8.8 individual/ha]) were captured from control plot. In 2020, four species (*M. meridianus* [3 individuals], *D. sagitta* [5 individuals], *P. roborovskii* [52.4±12.4 individual/ha] and *A.curtatus* [1 individual]) were trapped from rehabilitation and four species (*M. meridianus* [83.6±15.6 individual/ha], *D. sagitta* [85.2±72.8 individual/ha], *P. roborovskii* [2 individuals] and *A.curtatus* [1 individual]) were trapped from natural plot (Table 2). Other research (Oyu Tolgoi 2016, Oyu Tolgoi 2017) shows *P. roborovskii* population decreased in summer 2016; however, the population number increased in 2017 because of the precipitation.

Table 2 Loglinear models for closed small mammal population

Year	Plot	Species	Best fit model	Abundance	*SE*	df	AIC
2016	Natural	*M. meridianus*	Mt	29.2	2.80	3	23.12
2016	Natural	*P. roborovskii*	Mbh	44.4	15.2	3	20.0
2016	Rehab	*P .roborovskii*	M0	45.2	10.0	5	21.9
2017	Natural	*M. meridianus*	Mt	114.8	24.0	10	41.7
2017	Natural	*P .roborovskii*	Mt	116.4	64.4	3	23.5
2017	Natural	*D. sagitta*	Mbh	25.2	8.80	3	17.0
2017	Rehab	*P. roborovskii*	M0	70.8	15.2	13	36.2
2020	Natural	*M. meridianus*	M0	83.6	15.6	5	26.4
2020	Natural	*D. sagitta*	Mbh	85.2	72.8	3	17.7
2020	Rehab	*P. roborovskii*	M0	52.4	12.4	5	22.8

AIC = Akaike information criterion; df = Degrees of freedom; M0 = the capture probability at any capture occasion; Mt = the capture probabilities for each capture occasion; Mbh = the probability of first capture at any capture occasion;

The study showed that small mammal abundance in the natural plot was higher than small mammal abundance in the rehabilitation plot in GKh borefield area (Figure 7).

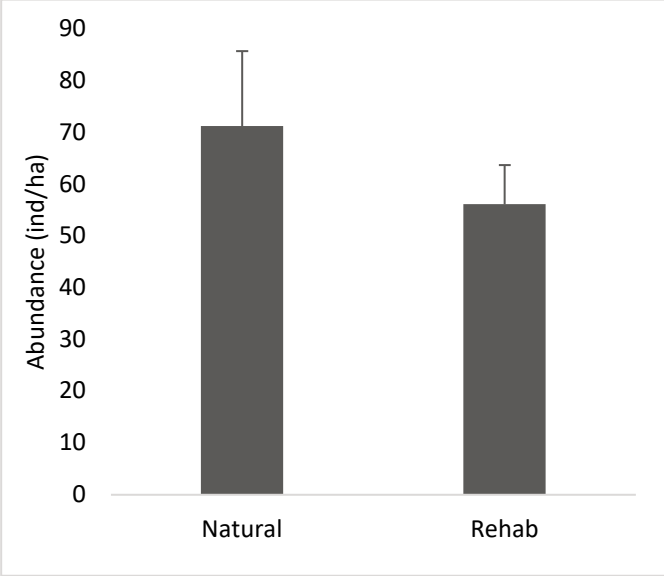

Figure 7 Average abundance of small mammal communities in natural and rehabilitation plots

5 Conclusion

The *P. roborovskii* was main dominant species at the all study plot during research period, which can be explained by homogeneous sandy habitats in desert and semi-desert preferred by this species (Batsaikhan 2014). Preliminary study results are showing that there is a rapid colonization of the rehabilitation areas; however, the natural saxaul forest has higher density six years after rehabilitation plantings were completed, also species diversity, species richness, and species evenness in rehabilitation plot became same to the natural saxaul forest. Most rehabilitation and closure monitoring is focusses on vegetation monitoring; the present study shows the importance of other types of monitoring to assess the function of the rehabilitated ecosystem. This study will be continued to develop a long-term evaluation of small mammals' succession in rehabilitated area. This study illustrates that other ecological end-points should be included in the monitoring of rehabilitation areas to assess the re-establishment of ecosystem function in areas rehabilitated after mining related activities have been completed.

Acknowledgement

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