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Dynamics of Soil Fauna in Da Hinggan Mountains, Northeast China

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Abstract: The dynamics of soil animals was studied in seven representative forest communities in the north of the Da Hinggan Mountains, Northeast China. The results indicate that it was distinctive in the changes of the numbers of soil animals and groups and diversity in relationship with seasons for macrofauna and meso-micro fauna in the study area. The numbers of the observed soil animals in different months were: October>August>June. Group number was larger in August and October, but smaller in June. The change of diversity index in different months was: August>June>October. The biomass for macrofauna in different months was: October>June>August. The composition and number of each functional group was relatively stable. In the community of the predominant soil environment, the percentage of saprophagous animals was higher than carnivorous animals and herbivorous animals. The dynamics changes of saprophagous and carnivorous animals were distinctive, increasing from June to October, while the change of herbivorous animals was unremarkable.

Keywords: soil animal; Da Hinggan Mountains; cold-temperate zone

1 Introduction

As important material decomposers, soil animals play an important role in ecosystems. Nowadays, with the rapid development of the ecosystem research, the research on the decomposers has relatively lagged behind, which constitutes a bottleneck in the ecosystem research. For this reason, the study on soil animals and their function has become the focus of ecology in the recent years and has been widely conducted in the aspects of the soil fauna, eco-geographical rules, the soil biodiversity and the function of soil animals at home and abroad (Huhtaa, 2006; Li and Chen, 1993; Yin, 1992; 2000; Coleman and Whitman, 2005; Fitter et al., 2005; Heneghan et al., 1998; Wang et al., 2002; McGrady-Steed et al., 1997; Chen and Fu, 1984; Fu et al., 2002；Jennifer et al., 2001; Yin et al., 2003). The Da Hinggan Mountains are one of the most important forest areas located in the cold-temperate zone of China. Up to now, a few of reports have been done on the soil animals in this region (Zhang et al., 2006).

In this paper, investigations and researches on composition and dynamics of soil fauna were conducted in Tahe County, which is located in the north of the Da Hinggan Mountains. Due to the climatic characteristics of the low-temperature in the cold-temperate zones, the decomposition activities of the soil fauna are mainly concentrated in the warm seasons from May to October. Thus, it is of great significance to study the diversity of composition, quantity, biomass and biodiversity of soil animals during this period for understanding the characteristics of soil fauna resources and eco-geographical rules and exploring their function in the ecosystem. In addition, it offers basic materials for the future research on the soil zoology in the cold-temperate zone.

2 Method

2.1 Study area

The study area is located in Tahe County (52°09′–53°23′ N, 123°19′–125°48′E) in the north of Heilongjiang Prov-

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ince, which lies on the north slope of Yilehuli Mountain in the Da Hinggan Mountains. It belongs to terrestrial monsoon cold-temperate climate zone, and has a long and cold winter from November to April next year, but a short and wet summer from July to August. The mean annual temperature is –2℃,mean annual precipitation is 428mm, and annual frost-free days are 80–100d.

In order to explore the characteristics of soil animals in different forest communities more comprehensively in the Da Hinggan Mountains, we chose different forest communities which were located in the same ecological range of the mountain in the vertical direction and on different mountains in the horizontal direction. In all seven forest communities chosen in Tahe County, communities Ⅰ, Ⅱ, Ⅲ, and Ⅳ were on the mountaintop, the mountainside, the piedmont and the valley respectively in the same mountainous area and communities Ⅴ and Ⅵ were typical forest communities located on other mountains. Community Ⅶ was *Salix* spp. meadow located in flood plain. Furthermore, the systematic survey of habitats and soil sampling analysis were conducted in the seven forest communities in June, 2003 (Table 1) .

Table 1 Characteristics of seven forest communities

	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ	Ⅵ	Ⅶ
Community	Broad-leaved mixed forest	Broad-leaved mixed forest	Broad-leaved *Larix gmelini* forest	*Larix gmelini* pure forest	*Quercus mongolica* forest	*Pinus Sylvestris* var. artificial forest	*Salix* spp. Meadow
Location	Mountaintop	Mountainside	Piedmont	Valley	Piedmont	Piedmont	Riverside
Vegetation	**Arbor** *Betula costata*, *Betula platyphylla*, *Quercus mongolica* **Shrub** *Rhododendron dahuricum* **Herbage** *Deyeuxia angustifolia*, *Sanguisorba officinalis*, *Majanthemum bifolium*, *Vicia* spp.	**Arbor** *Betula platyphylla*, *Populus* spp., *Larix gmelini*, *Betula costata*, *Betula davurica* **Shrub** *Rhododendron dahuricum*, *Vaccinium vitisidaea* **Herbage** *Deyeuxia angustifolia*, *Sedum aizoon*, *Majanthemum bifolium*	**Arbor** *Betula platyphylla*, *Larix gmelini* **Shrub** *Rhododendron dahuricum*, *Padus maackii*, *Sorbaria sorbifolia*, *Rubus* spp., *Spiraea* spp., *Deutzia amurensis*, *Clematis* spp. **Herbage** *Deyeuxia angustifolia*, *Sanguisorba officinalis*, *Majanthemum bifolium*	**Arbor** *Larix gmelini* **Shrub** *Rhododendrn dahuricum*, *Vaccinium vitisidaea* **Herbage** *Carex* spp., *Filipendula palmata*, *Geranium* spp.	**Arbor** *Quercus mongolica*, *Larix gmelini* **Shrub** *Spiraea* spp., *Lespedeza bicolor* **Herbage** *Carex callitirchos*, *Iris* spp., *Vicia* spp., *Veratru dahuricum*, *Polygonatum odoratum*, *Thalictrum* spp., *Geranium* spp.	**Arbor** *Pinus sylvestris* var., *Quercus mongolica* **Herbage** *Carex callitirchos*, *Iris* spp., *Vicia* spp., *Veratru dahuricum*, *Sedum aizoon*, *Thalictrum* spp., *Geranium* spp.	**Shrub** *Salix* spp., *Alnus hirsuta*, *Ribes* spp. **Herbage** *Potentilla* spp., *Diarrhena mandshurica*, *Moehringia lateriflora*, *Agrimonia pilosa*, *Filipendula palmata*, *Caradamine leucantha*, *Taraxacum* spp., *Plantago asiatica*
Arbor coverage (%)	40	80	80–90	60–70	55–70	80–90	0
Shrub coverage (%)	30	80–90	20	20	50	10	40
Herbage coverage (%)	80–90	80–90	100	100	80–90	>90	60–70
Litter mass (g/m^2)	915	1391	1053	1322	1388	812	443
Water content (%)	62.09	72.37	61.22	69.9	56.11	52.42	36.34
pH	5.13	4.76	5.38	5.03	5.85	5.58	6.06
Total nitrogen (%)	0.47	1.33	1.14	1.08	0.49	0.37	0.21
Organic matter (%)	8.01	42.73	38.63	32.9	6.05	6.12	1.75

2.2 Methods

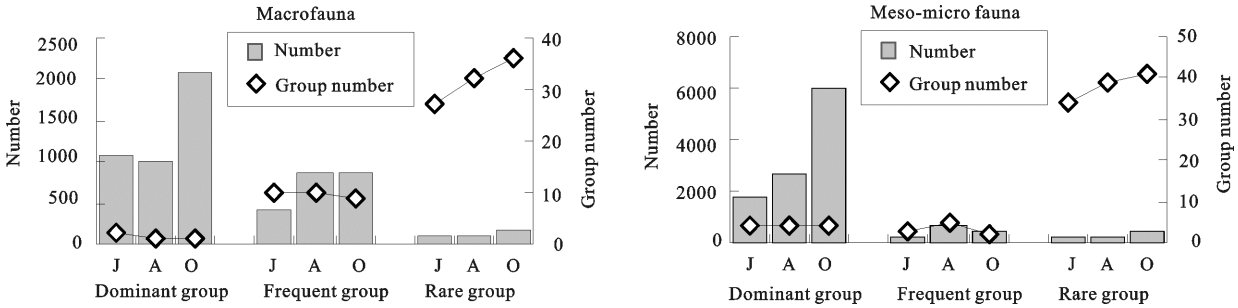
In this study, samples from seven communities were collected in June (Spring), August (Summer) and October (Autumn) of 2003, and in each community four sampling sites were chosen randomly. Samplings were separately finished for the macro soil fauna and meso-micro soil fauna. For the macro soil fauna, at each site we sampled the soil in 3 layers, i.e., litter layer, 0–5cm and 5–10cm, and the sampling area was 50cm× 50cm. The soil animals were collected by hand, and preserved in 75% ethanol. We did not get the litter layer in Community Ⅶ in October, so the total samples were 248. For the meso-micro soil fauna, the sampling area was 10cm×10cm, and sampled in 4 layers, i.e., litter layer, 0–5cm and 5–10cm and 10–15cm, and we got 336 samples in total. The samples were thereafter analyzed in the laboratory and picked up by the Tullgren method. We did taxonomy and data processing for the sampled soil animals and measured the biomass of macrofauna (fresh weight).

3 Results

3.1 Soil fauna composition

In total, we collected 6729 individuals of 67 groups of macrofauna. Enchytraeidae was the dominant group (more than 10% of the total number), accounting for 58.5% of the total number; ten frequent groups (1% to 10% of the total number) were found, i.e., Formicidae, Lithobiomorpha, Gastropoda, Geophilomorpha, Araneae, Carabidae, Staphylinidae, Lumbricidae, Juliformia and Elateridae, accounting for 35.9% of the total number. Twenty-three common groups were found in June, August and October. Enchytraeidae was the common dominant group of June, August and October. The specific dominant group in June was Formicidae, because the sampling sites were near Formicidae nests. The common frequent groups were Lithobiomorpha, Gastropoda, Geophilomorpha, Araneae, Carabidae, Staphylinidae, Lumbricidae and Elateridae. The specific frequent group in June was Noctuidae.

In total, we found 12,841 meso-micro soil animals belonging to 61 groups. The dominant groups were Mesostigmata, Oribatida, Prostigmata and Isotomidae, accounting for 80.0% of the total number. Frequent groups are Onychiuridae, Chironomidae and Pseudachorutidae, accounting for 12.4% of the total number. There were 34 common groups in June, August and October. The common dominant groups were Mesostigmata, Oribatida and Prostigmata and the common frequent group was Pseudachorutidae in the three seasons. The specific frequent groups in June were Isotomidae and Oncopoduridae. The specific frequent groups in August were Chironomidae, Enchytraeidae and Tabanidae. Numbers and group numbers of dominant, frequent and rare groups in different seasons are shown in Fig. 1.



J: June; A: August; O: October

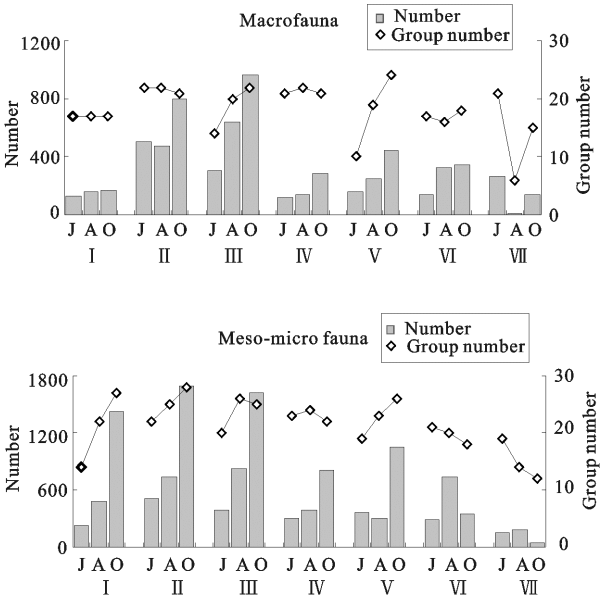
Fig. 1 Dynamics of dominant, frequent and rare groups of soil fauna

Dynamics of number for macrofauna was consistent with that of meso-micro fauna. The number of dominant groups was lower in June and August, while it was higher in October which was more than the total number of June and August. The number of frequent groups was lower in June, but higher in August and October. Dynamics of rare groups was unremarkable, increasing from June to October. Dynamics in numbers of dominant and frequent groups is unremarkable.

3.2 Number and group number of soil fauna

In total, the number and group number of the macrofauna in different months were: October (3124, belonging to 46 groups)>August (1994, belonging to 43 groups)>June (1611, belonging to 39 groups). Dynamics of the number of macrofauna in most communities were consistent with that of the total number, but group numbers were unremarkable in different seasons. The number and the group number of Community Ⅶ were the most in June, but the least in August, which was inconsistent with the dynamics of other communities. This is because that the sampling sites were near Formicidae nests in June, which made the number and the group number increased obviously on the one hand, and the river just ebbed, and litter layer was thin in August, which made the soil was not suitable for macrofauna on the other hand. From August to October, with the soil environment improving, soil animals increased in number again.

The number of the meso-micro fauna increased from June (2221) to August (3633) and increased again to October (6987). The group number was greater in August (48) and October (47), and smaller (41) in June. The dynamics of number of the meso-micro fauna for most communities was consistent with that of the total number, but the dynamics of the group number was unremarkable (Fig. 2).



J: June; A: August; O: October

Fig. 2 Dynamics of number and group number of soil animals in communities Ⅰ–Ⅶ

3.3 Diversity index of soil fauna

Shannon-Wiener index was used to discuss the diversity of soil animals. The diversity index of macrofauna in different months was: August (1.9929)>June (1.9077)> October (1.5114). Most communities did not show any consistent trend. Among the communities, the diversity indices of Communities Ⅰ and Ⅶ were greater in October, but almost the same in June and August. The diversity indices of Communities Ⅱ, Ⅲ and Ⅳ were consistent, i.e., August>June>October. For Community Ⅴ, it was: August>October>June and for Community Ⅵ, it was much greater in June than in August and in October (Table 2).

The diversity index of meso-micro fauna was: August (2.1927)>June (2.1136) >October (1.8670), which was consistent with that of the macrofauna. The diversity indices of Communities Ⅰ, Ⅱ, Ⅲ and Ⅴ in different months were: August>June>October. For Community Ⅳ, it was almost the same in June and August, but smaller in October. For Community Ⅵ, the index was: June>October>August. For Community Ⅶ, it was smaller in August, but greater in June and October. In different seasons, the diversity index was inconsistent with that of the total change in each community (Table 2).

3.4 Biomass of macrofauna

The biomass of macrofauna per unit area in different months was: October (4.731g/m^2)>June (2.528g/m^2)>August (1.873g/m^2), and inconsistent with the change of the number, mainly because of the great difference between the biomass of different species. In all of the collected macrofauna, the mean biomass was 0.0095g. The largest soil specimen was Limacidae (only one collected), whose biomass was 0.2639g. The second largest was Lumbricidae, and the mean individual biomass was 0.1847g. In addition, biomass of *Tipulidae larvae* and *Notodontidae larvae* were 0.1520g and 0.0997g respectively. The smallest mean individual biomass was less than 0.0001g. Great difference existed even in the same species. Except some communities, the biomass of most communities changed with the total biomass (Fig. 3).

The proportion of biomass of each group to the total was completely different in the different seasons. In June, it was in order of Lumbricidae≈Insecta and larvae>Enchytraeidae>Chilopoda≈Arachnida≈Gastropoda> Diplopoda. In August, it was in order of Lumbricidae>Enchytraeidae>Insecta and larvae>Gastropoda> Arachnida>Diplopoda. And in October, it was in order

Table 2 Dynamics of diversity index of different communities

	Month	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ	Ⅵ	Ⅶ	Total
Macrofauna	June	1.8872	1.4167	1.2540	2.1983	1.2558	2.0351	1.6345	1.9077
	Aug.	1.7426	1.9179	1.7725	2.5051	1.9484	1.0925	1.5942	1.9929
	Oct.	2.2221	1.2447	0.8978	1.4986	1.5551	0.9810	1.8445	1.5114
	Total	2.2808	1.5467	1.3798	2.0757	1.6813	1.3402	1.8778	
Meso-micro fauna	June	1.9352	1.8329	2.0903	1.9928	1.6033	2.0182	2.0629	2.1136
	Aug.	2.1320	2.0232	2.1525	1.9827	2.0652	1.4614	1.8691	2.1920
	Oct.	1.5545	1.7564	1.9707	1.7497	1.4378	1.8744	2.0922	1.8670
	Total	1.8930	1.9291	2.1898	1.9444	1.7384	1.8761	2.2225	

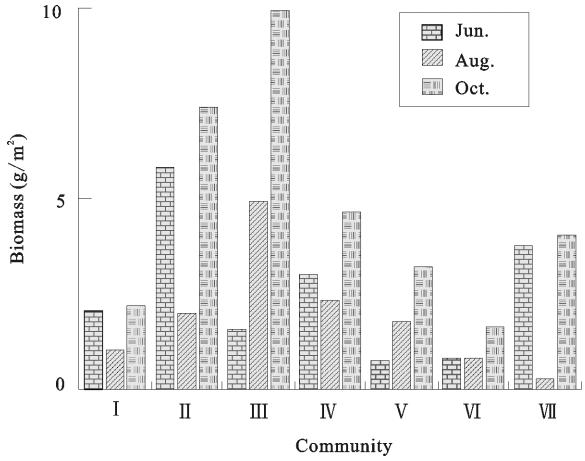


Fig. 3 Dynamics of biomass of macrofauna per unit area

of Enchytraeidae>Lumbricidae>Insecta and larvae>Chilopoda>Gastropoda≈Arachnida>Diplopoda (Fig. 4).

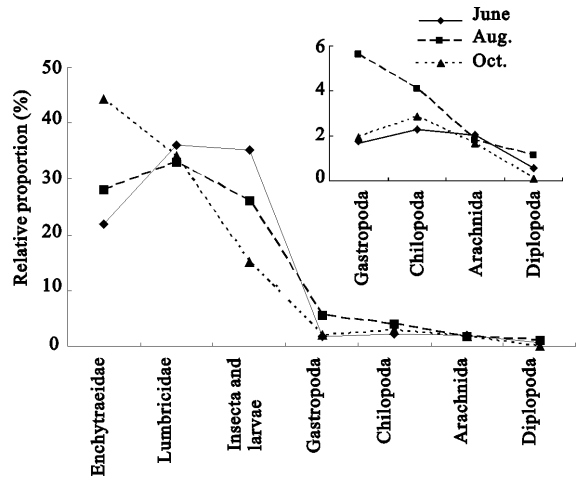


Fig. 4 Dynamics of relative proportion of biomass in different groups

3.5 Composition and number of soil fauna in each functional group

Soil animals are abundant in variety, and there are great differences in size, living ability and living style. However, many species are the same in function and thus form some functional groups. The members of a functional group play a similar ecological function in the system, taking up the same niche, but are different in composition. For the convenience of doing research, Li and Chen (1993) suggested to classify the soil animals according to their functions in an ecosystem. Zhang et al. (2001) divided the soil animals into three functional groups, i.e., herbivorous, carnivorous, saprophagous animals, based on the research on Liangshui area and Mao'er Mountains of Heilongjiang Province, Northeast China. This kind of classification helps to simplify the research and to discuss the functions of soil animals in forest ecosystems.

According to the statistical methods of functional groups of soil animals, it was found that the herbivorous, carnivorous, saprophagous soil animals took up 66.8%, 13.4%, 19.8% of the total respectively. Changes of composition and number of each functional group are shown in Table 3.

Among different functional groups, the number of saprophagous animals changed distinctively in different months, increasing from June, August to October and the number in October was more than the sum in June and August. The change in the number of herbivorous group was unremarkable in different seasons. Carnivorous animals were fewer in June, but increased in August and October. The change of the number of soil animals in each functional group with its specific environment and the distribution rule of soil animals on the whole was different.

Table 3 Dynamics of composition and number of each functional group

		June	August	October	Total
Saprophagous animial	Enchytraeidae	839	1002	2094	3935
	Lumbricidae	26	34	59	119
	Gastropoda	44	87	98	229
	Juliformia	24	61	15	100
	Limacidae		1		1
	Diptera	33	28	28	89
	Others		14	7	21
	Total	966	1227	2301	4494
Herbivorous animal	Coleoptera	58	47	88	193
	Hemiptera	12	26	18	56
	Lepidoptera	20	6	9	35
	Formicidae	240	189	183	612
	Others	1	1	4	6
	Total	331	269	302	902
Carnivorous animal	Lithobiomorpha	99	180	192	471
	Geophilomorpha	61	93	70	224
	Araneida	58	48	83	189
	Pseudoscorpiones			2	2
	Opiliones			1	1
	Predatory insects	96	177	173	446
	Total	314	498	521	1333
Total		1611	1994	3124	6729

4 Conclusions

In June, August and October, 2003, the dynamics of soil fauna was studied in seven representative forest communities in the north of the Da Hinggan Mountains, Northeast China. The conclusions were as follows:

(1) Number of dominant groups was lower in June and August, but higher in October both for macro and meso-micro fauna. But for frequent groups, it was lower in June, but higher in August and October. It was unremarkable for rare groups. Dynamics of numbers in dominant and frequent groups were unremarkable, but for rare groups it increased from June to October.

(2) The regularities of the changes in the number, group number and diversity of soil animals were almost the same for macrofauna and meso-micro fauna. The number of soil individuals in different months was: October>August>June. The group number was larger in August and October, but smaller in June. The trends of the dynamics of the number of soil animals in most communities were consistent with that of the total number, but group number showed inconsistency. The diversity index in different months was: August >June> October. Some communities showed their own different changing regularities with their specific environment.

(3) The changes of the biomass for macrofauna in different months was: October>June>August. It was inconsistent with the trend of the number, mainly because biomass of each species was different between different species. Even within the same species, the great difference existed individually. Except some communities, biomass of most communities coincides with the trend of the total biomass.

(4) There was a relative stability in the composition and number of the functional groups. In predominant environment, the number of saprophagous animals was large. Numbers of saprophagous and carnivorous animals increased from June to October, while the change of the number of herbivous animals was unremarkable.

(5) Due to the restriction of environmental factors such as climate, large gradients of disturbance, edaphic properties, geographic area and resources quality, species richness in the study area was lower than that of subtropical and tropical areas. At present, little research has been done on soil animals in the cold-temperate zone of China. Much more studies would need to be done to reveal the ecological distribution rules of soil animals in this zone.

References

Chen Peng, Fu Deyi, 1984. Study on the function of soil animals in cycle of material in Changbai Mountains. *Acta Ecologica sinica*, 4(2): 1–9. (in Chinese)

Coleman D C, Whitman W B, 2005. Linking species richness, biodiversity and ecosystem function in soil systems. *Pedobiologia*, 49: 479–497. DOI: 10.1016/j.pedobi.2005.05.006

Fitter A H, Gilligan C A, Hollingworth K et al., 2005. Biodiversity and ecosystem function in soil. *Functional Ecology*, 19: 369–377. DOI: 10.1111/j.1365-2435.2005.00969.x

Fu Biqian, Chen Wei, Dong Xiaohui, 2002. The composition and structure of the four soil macro-faunas in Songshan Moutain in Beijing. *Acta Ecologica Sinica*, 22(2): 215–223. (in Chinese)

Heneghan L, Coleman D C, Zou X et al., 1998. Soil microarthropod community structure and litter decomposition dynamics: A study of tropical and temperate sites. *Applied Soil Ecology*, 9: 33–38.

Huhtaa V, 2006. The role of soil fauna in ecosystems: A historical review. *Pedobiologia*, 50(6): 489–495. DOI: 10.1016/j.pedobi.2006.08.006

Jennifer L D, Rick J Z, John C M, 2001. Soil microarthropod community structure and dynamics in organic and conventionally managed apple orchards in western colorado, USA. *Applied Soil Ecology*, 18: 83–96.

Li Jingke, Chen Peng, 1993. *Research on Soil Fauna Ecogeography*. Changchun: Northeast Normal University Press. (in Chinese)

McGrady-Steed J, Harris P M, Morin P J, 1997. Biodiversity regulates ecosystem predictability. *Nature*, 390: 162–165.

Wang Zhenzhong, Zhang Youmei, Xing Xiejia, 2002. Effect of change in soil environment on community structure of soil animal. *Acta Pedologica Sinica*, 39(6): 892–897. (in Chinese)

Yin Wenying, 1992. *Subtropical Soil Animals of China*. Beijing: Science Press. (in Chinese)

Yin Wenying, 2000. *Soil Animals of China*. Beijing: Science Press. (in Chinese)

Yin Xiuqin, Wu Donghui, Han Xiaomei, 2003. Diversity of soil animals community in Xiao Xingan Mountains. *Scientia Geographica Sinica*, 23(3): 316–322. (in Chinese)

Zhang Xueping, Hou Weiling, Chen Peng, 2001. Soil animal guilds and their ecological distribution in the northeast of China. *Chinese Journal of Applied & Environmental Biology*, 7(4): 370–374. (in Chinese)

Zhang Xueping, Zhang Shuhua, Li Jingke, 2006. Eco-geographical analysis of soil animals in burned forest areas in Greater Hinggan Mountains. *Geographical Research*, 25(2): 327–334. (in Chinese)