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ECOLOGICAL SERIES OF SOIL ANIMALS IN DARLIDAI MOUNTAIN

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ABSTRACT: The ecological series of soil animals under the broad-leaved and pine mixed forest in Darlidai Mountain was studied. Seven sample plots were selected according to different altitude gradients, which belong to different vegetation types. By investigating and analyzing soil animals in every sample plot it is found that there are 45 groups and 1956 individuals, which are involved in 3 phylums, 7 classes, 16 orders, respectively. The altitude is a key factor which affects ecological series of soil animals. Both the groups and individuals of soil animals increase with altitude increasing under certain conditions, which contrastes with ordinary cases, resulting from special micro-climate in studied area. The groups and individuls of soil animals are the most under the broad-leaved and pine forest on the top of the mountain, and the least under *Picea-Abies* forest in the foot of the mountain.
KEY WORDS: Darlidai Mountain; soil animals; ecological series

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Ecological series of soil aminals is a result of variations of biological populations or communities caused by gradient differences of one or some environment factors. R H Whittaker had ever studied ecological series of soil animals (WHITTAKER, 1986). A little information on ecological series of soil animals has been known in China. This paper studies the gradual variance regularities of soil animals and environmental factors, and the relationship of them, in order to reveal some regularity in the ecological series of soil animal.

1 WORKING METHOD

1. 1 Sample Plot Selection

This study was conducted in the Liangshui Nature Reserve. It lies in the east slope of a branch of Darlidai Mountain, to the south of Xiao Hinggan Mountains (Fig. 1). Here, the natural vegetation is well protected and there are spreading plots of wild woods with little human intervention.

The sample plots are on a hill in the center of the reserve area. It is 800m above sea level. The height between the peak and the foot of the hill is 130m. Soil type is dark brown soil. With the altitude increasing, the changes of vegetation is obvious. On the basis of 20-meter in vertical discrepancy, altogether 7 sample plots were selected. Their vegetation types are: (Ⅰ. *Picea-Abies* forest(10m); Ⅱ. *Betula platyphylla* forest(30m); Ⅲ. *B. Costata* and pine forest(50m); Ⅳ. *Larix* forest(70m); Ⅴ. Broad-leaved and *Larix* forest(90m); Ⅵ. *Picea-Abies* and pine forest(110m); Ⅶ. Broad-leaved and pine forest(130m), respectively (HOU and ZHANG, 2000).

1. 2 Sampling Method

Three repeated samples were taken in each sample plot. The area of each sample is 50cm × 50cm. From each sample plot, samples of litter and soil in 0 – 10cm depth were collected. Altogether $2 \times 3 \times 7 = 42$ samples were collected. Then soil animals were sorted out by hand(CHEN and ZHANG, 1986). In the middle of August of 1995 and the middle of August of 1996, two samplings were done(lasting 6 days for each time) in the Liangshui Nature Reserve. While taking samples,

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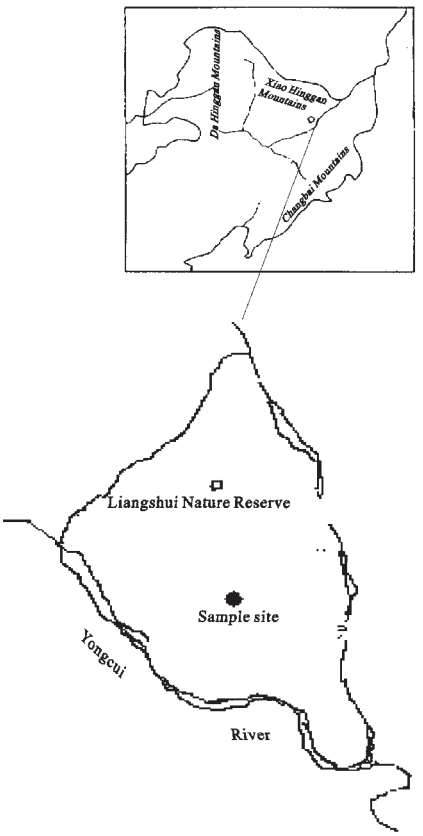

Fig. 1 Sketch of the location of study area

environmental factors and plant communities were investigated.

2 RESULTS AND ANALYSES

2.1 Composition of Groups and Amount of Soil Animals

In seven sample plots, 45 groups of soil animals are collected, whose amount of individuals are 1956 (Table 1), which belong to 3 phylums, 7 classes, 16 orders. Table 1 shows that there are 2 kinds of dominant groups (CHEN *et al.*, 1990; ZHANG *et al.*, 1980): Enchytraeidae(52.20%) and Lithobiidae(10.12%); 7 usual groups: Juliformia (6.08%), Lumbricidae (5.98%), Geophilidae (5.16%), Coleoptera larva (3.83%), Araneida(3.78%), Diptera larva(3.22%), Formicidae(1.79%); and 36 rare groups ①. Changes of groups and individuals of soil animals with altitude gradient are shown in Fig. 2.

Fig. 2 shows that the groups and individual number of soil animals increases in general, from mountain foot to mountain top. However, the change of the biological species and individual number with altitude gradient here are contrary to the regular variation of ecological series of soil animals, due to the special micro-climate (HOU, 1990). In the bottom of mountain valleys there are island-shaped eternal frozen layer in soil, resulting in adverse temperature valley, where temperature rises with altitude. So the local vegetation type(ZHANG *et al.*, 2001), i.e. broad-leaved and pine forest is formed on top of the mountain, where there are the most of biological groups and individuals, including soil animals. In Fig. 2, both the groups and individuals of soil animals drop in sample plots Ⅳ and Ⅵ, which is related to the vegetation type and microclimate in the communities. These two plots are both needle-leaved forest. There are scarce bushes and grasses under the trees. It is colder and wetter in the forest than in others, so there are less of groups and individuals of soil animals. The groups and individuals of soil animals are the least in sample plot Ⅰ, whose vegetation is *Picea-Abies* forest, in which the temperature is much low, and there is thick litter that is hard to be decomposed, no bush and little grass, so there are least groups and individuals of soil animals.

2.2 Analyses of Diversity and Similarity of Groups

The diversity is shown with the Menhinick′s abundance index(D) (CHAPMAN, 1981):

$$D = \ln S / \ln N$$

where S—number of groups of soil animals;

N—number of individuals of soil animals.

The results are shown in Table 2.

Fig. 3 shows the changes of the abundance index of soil animals in sample plots with altitude gradient. From the changes of the abundance index, we can see that, except sample plot Ⅵ (110m), all the abundance indexes rise with the altitude gradient increasing. At the peak (sample plot Ⅶ) the abundance index is the highest, and that in sample plot I is the lowest. It sufficiently shows the feature of adverse temperature valley. In sample plot Ⅰ, where there is Picea – Abies, the abundance of soil animals is smaller than others.

The similarity of soil animals in the communities is shown by Sorensen index (C_s):

$$C_s = \frac{2S_c}{S_A + S_B}$$

where S_C—Common groups in both A and B communities;

① They are classified according to the proportion of the individuals of a group to total individuals: > 10% is dominant group, 1% – 10% is usual group, <1% is rare group.

Table 1 Statistics of soil animals

No.	Soil animals	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ	Ⅵ	Ⅶ	∑	%
1	Enchytraeidae	101	123	122	133	145	161	236	1021	52.20
2	Lithobiidae	11	18	14	11	53	52	39	198	10.12
3	Juliformia	11	10	16	18	20	22	22	119	6.08
4	Lumbricidae	15	13	18	18	17	13	23	117	5.98
5	Geophilidae	15	9	11	13	21	15	17	101	5.16
6	Coleoptera larva	9	5	4	12	18	16	11	75	3.83
7	Araneida	6	6	7	11	15	12	17	74	3.78
8	Diptera larva	5	7	15	8	12	7	9	63	3.22
9	Formicidae	5	4	6	3	6	3	8	35	1.79
10	Lepidoptera larva		2	2	1	2	4	3	14	0.72
11	Scarabaeidae Larva		1	2	2	1	3	3	12	0.61
12	Valloniidae		3	1	1	1	1	3	10	0.51
13	Staphylinidae			1	1	1	3	4	10	0.51
14	Carabidae		4		1	1	2	1	9	0.46
15	Staphylinidae larva			1	1	2	1	2	7	0.36
16	Pentatomidae		1	2		2		1	6	0.31
17	Coleoptera	1			1	1	1	1	6	0.31
18	Tomoceridae		1	1	2	1		1	6	0.31
19	Onychiuridae		1		1	1	1	1	5	0.26
20	Chironomidae larva		1	1	1	1		1	5	0.26
21	Histeridae	1		1		1	1	1	5	0.26
22	Coccinellidae larva				1	1	1	1	4	0.20
23	Elateridae larva			1	1		1	1	4	0.20
24	Limacidae		2	1	1				4	0.20
25	Aphididae				1		2	1	4	0.20
26	Cochlicopidae					1	1	2	4	0.20
27	Pseudoscorpionida				1	1		1	3	0.15
28	Scarabaeidae			1		1		1	3	0.15
29	Platypus				1	1	1		3	0.15
30	Carabidae					2		1	3	0.15
31	Cicadadae larva	2		1					3	0.15
32	Machilidae					2		1	3	0.15
33	Curculionidae		1			1			2	0.10
34	Tabanidae larva						1	1	2	0.10
35	Muscidae					1		1	2	0.10
36	Cecidomyiidae						1	1	2	0.10
37	Cicindlidae		1	1					2	0.10
38	Ichneumonidae						1	1	2	0.10
39	Cryllacridae					1		1	2	0.10
40	Geophilellidae				1				1	0.05
41	Phalangida							1	1	0.05
42	Cicadidae		1						1	0.05
43	Chalcidae							1	1	0.05
44	Noctuidae			1					1	0.05
45	Thripidae							1	1	0.05
$\sum S^*$		12	21	24	26	31	26	36	45	
$\%\ (S_i/S)$		26.67	46.67	53.38	57.78	68.89	57.78	80		
$\sum N^*$		182	214	231	246	335	327	421	1956	
$\%\ (N_i/N)$		9.3	10.94	11.81	12.58	17.13	16.72	21.52		

* S—groups N—Number of soil animals

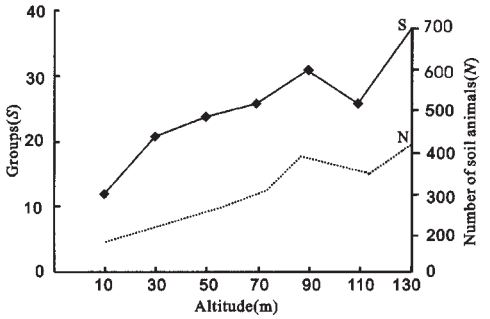

Fig. 2 The variation of groups and number of soil animals with altitude gradient

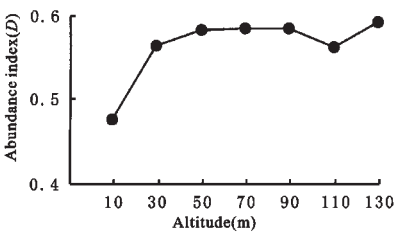

Fig. 3 The variation of community abundance index with altitude gradient

Table 2 The abundance index of sample plots

	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ	Ⅵ	Ⅶ
D value	0.4775	0.5674	0.5839	0.5851	0.5852	0.5624	0.5928

S_A—groups in A community;

S_B—groups in B community.

The calculation results are shown in Table 3.

Table 3 shows that C_s between sample plot Ⅵ and Ⅶ is the largest and C_s between sample plot Ⅰ and Ⅶ is the smallest. In corresponding with it, the similarity between soil animals in sample plot Ⅵ and Ⅶ is the largest, and that in sample plot Ⅰ and Ⅶ is the smallest. The reason is because of the microclimate in the *Picea-Abies* forest and of the fact that the litter is slowly decomposed and there are less grasses, which result in that there are less groups and individuals of soil animals.

Table 3 The Sorensen index of communities (C_s)

	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ	Ⅵ	Ⅶ
Ⅶ	0.4583	0.5965	0.6667	0.7213	0.7879	0.8065	1
Ⅵ	0.5789	0.5957	0.64	0.7843	0.7143	1	
Ⅴ	0.5238	0.7059	0.7037	0.8	1		
Ⅳ	0.5405	0.6957	0.7347	1			
Ⅲ	0.6111	0.7555	1				
Ⅱ	0.5455	1					
Ⅰ	1						

2.3 Correlation Between the Groups of Soil Animals

The correlation between the groups of soil animals is shown with the combination index (*IA*):

$$IA = C/(a + b + c)$$

where a—sample number of group A′s single appearance;

b—sample number of group B′s single appearance;

c—sample number of group A and B′s common appearance.

In the 45 groups of soil animal, there are 29 groups (Table 1) that appear in more than 3 communities. Calculating the combination index shows that the largest index is 100, and the smallest is 0. There exist the most significant correlations among Enchytrbaeidae, Lithobiidae, Juliformia, Lumbricidae, Geophilidae, Coleoptera larva, Araneida, Diptera larva and *F*omicidae. They appear in all the communities. Though not appearing in all communities, the most significant correlation among Lepidoptera larva, Scarabaeidae larva and Vallonidae in the same community has been presented. The combination indexes between Cicadadae larve and Carabidae, Onychiuridae and Coccinellidae larva are both zero and they never appear in the same community. The No. 30 – No. 45 soil animals (Table 1) only appear in 1 or 3 communities, and their correlation with No. 1 – No. 29 groups is very small.

2.4 The Analysis of Environmental Factors

Here 5 environmental factors, such as, relative altitude, temperature and water contents of 0 – 10cm depth and 10 – 20cm depth in soil were selected, measured and analyzed as variables, and the results are shown in Table 4.

Principal component M = 2.

The accumulative contribution rate of variables X_1, X_2 and X_3 is 0.9891 (Table 5). It shows that altitude is the leading factor for the ecolgoical series of soil animal in the environmental gradient.

The principal component load (Table 6) demonstrates that the positive correlations between principal component Ⅰ and variables X_1, X_2 and X_3 are most significant, showing Ⅰ is the principal component of altitude, because X_1, X_2 and X_3 all related to altitude. Also, the positive correlations between principal component Ⅱ and variable X_4 and X_5 are most significant, which are both water contents in the soil, so Ⅱ is the principal component of soil moisture.

Table 4 The observation of environmental factors

Environmental factor	Community						
	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ	Ⅵ	Ⅶ
Relative altitude (m)	10.6	30.0	50.0	70.0	90.0	110.0	130.0
Soil temperature in 0 – 10cm (℃)	20.5	19.5	20.5	21.5	20.5	20.0	22.0
Soil temperature in 10 – 20cm(℃)	13.0	13.5	14.5	15.0	14.0	14.5	16.0
Soil water in 0 – 10cm(%)	9.6	15.4	6.2	10.2	6.6	6.7	6.7
Soil water in 10 – 20cm(%)	7.1	10.5	5.3	6.9	4.5	3.8	5.5

Table 5 The eigenvalue and ratio of contribution of factors

Environmental Factor	Variable	Eigen-value	%	Accumula-tive rate
Relative altitude (m)	X_1	2.7916	0.5583	0.5583
soil temperature in 0 – 10cm (℃)	X_2	1.7315	0.3463	0.9046
soil temperature in 10 – 20cm (℃)	X_3	0.4226	0.0845	0.9891
soil water in 0 – 10cm (%)	X_4	0.0487	0.0098	0.9989
soil water in 10 – 20cm (%)	X_5	0.0056	0.0011	1.0000

Table 6 Values of principal components

Principal component	Variable				
	X_1	X_2	X_3	X_4	X_5
Ⅰ	0.8357	0.8241	0.7948	0.6235	– 0.6275
Ⅱ	0.1848	0.4089	0.59069	0.7753	0.7615

3 CONCLUSIONS

(1) In Darlidai Mountain, there are 1956 individuals, 45 groups of soil animals in ecological series of 7 sample plots, they belong to 16 orders, 7 classes, 3 phylums, respectively. There are 2 dominant groups, 7 usual groups, 36 rare groups.

(2) The distributing regularity of the soil animals according to ecological series is: the number of groups and individuals of soil animals increase with the altitude rising, which is contrary to common situations, because it is the result of the special micro climate in adverse temperature valley.

(3) The composition and distribution of soil animals have been affected by vegetation type. The groups and individuals of soil animals in the *Picea-Abies* forest are smaller than that in other communities.

(4) Of the environmental factors in the ecological series, altitude is the leading one. The variables of other factors depend on it, so altitude markes the position of the complex environmental gradient.

(5) In the ecological series of soil animals, there exist the most significant correlations among Enchytraeidae, Lithobiidae, Juliformia, Lumbricidae, Geophilidae, Coleoptera larva, Araneida, Diptera larva and Fomicidae. They appear in all the communities. Cicadadae larva and Carabidae, Onychiaridae and Coccinellidae larva never appear in the same community, showing repulsion. However, whether this phenomenon is inevitability or by chance would be still studied in furture.

REFERENCES

CHAPMAN S B, 1981. *Methodology of Plant Ecology*[M]. Beijing: Science Press. (English was translated into Chinese)

CHEN Peng, SUN Fan and PU Zhao-yi, 1990. Study on investigation of soil animals in Northeastern China[J]. *Journal of Northeast Normal Unviersity(Nature Science)*, 22(1): 1 – 13. (in Chinese)

CHEN Peng, ZHANG Yi, 1986. Soil animal communities of the mixed forest zone on Changbai Mountains in China[J]. *Edaphology*, 35: 39 – 45. (in Japanese)

HOU Wei-ling, 1990. A study on the ecological series of soil animals in Yitong River Valley-Dahei Mountain of Jinlin Province[J]. *Journal of Northeast Normal University(Nature Science)*, 22(1): 93 – 101. (in Chinese)

HOU Wei-ling, ZHANG Hua, 2000. Ecological distribution of soil animals in broad-leaved and pine forest in southern slope of Xiao Hinggan Mountains[J]. *Chinese Geographical Science*, 10(3): 276 – 281.

WHITTAKER R H, 1986. *Plant Community Series*[M]. Beijing: Science Press. (English was translated into Chinese).

ZHANG Xue-ping, HOU Wei-ling, CHEN Peng, 2001. Soil animals guids and their ecological distribution in the Northeast of China[J]. *Journal of Applied and Environmental Biology*, 77(4): 370 – 374. (in Chinese)

ZHANG Yong-zu *et al.*, 1980. A preliminary investigation on soil animals in the forest ecosystem on the northern slope of Changbai Mountains. In: *Research of Forest Ecosystem*[M]. Beijing. Science Press, 133 – 152. (in Chinese)