Paper ID: 386
Theme 2. Grassland production and utilization
Sub-theme 2.3. Soil-plant-animal-human interrelationships

Dynamic of soil mesofauna of fixed sand dunes on the Songnen Grasslands, Northeastern China

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Keywords: Fixed sand dune, Grasslands, Soil mesofauna, Songnen, Topographic position

Introduction

Grasslands cover vast land areas in semi-arid and semi-humid regions. Sand dunes, most of which are fixed sand dunes, form a large portion of grasslands. Vegetation on fixed sand dunes is an important part of grassland ecosystem productivity, and topographic position is one of the important factors resulting in the differences among vegetation, soil, etc. (Sakai and Ohsawa, 1994; Nagamatsu and Miura, 1997).
An important component of soil fauna ecology is to analyze the distribution of soil fauna and its influencing factors. On the small scale, the ozone factors become the dominant factor affecting the soil fauna (Frouz *et al.*, 2011). Topographic position is an important factor affecting the distribution of soil fauna on fixed sand dunes (Xin *et al.*, 2013). This paper takes fixed sand dunes on the Songnen Grasslands as the research objects, and aims to determine the structure and diversity of soil mesofauna on the different positions of the fixed sand dunes.

Materials and Methods

Site description: The experiment was carried out in the southern part of the Songnen Grasslands (43°59´-44°42´N, 123°6′-124°45′E). Landform belongs to the alluvial plain covered by sand dunes, the relative height of which is 10 m. The area is located in a temperate sub-humid continental monsoon climate zone; the annual average precipitation is 360-480 mm. The annual average temperature is 4.9℃, and the soil is sand soil. Natural vegetation coverage accounts for more than 40%, and the main plants are *Ulmus pumila*, *Armeniaca sibirica*, *Stipa baicalensis*, *Agropyron cristatum*, *Lespedeza davurica*, *Achnatherum avinoides*, and *Cleistogenes squarrosa*.

Research method: We selected five topographic positions on the fixed sand dunes, and sampled in the spring (April), summer (June) and autumn (October) of 2010. The five topographic positions were the base of the south-facing slope (BSS), the middle of the south-facing of slope (MSS), the top of the slope (TS), the middle of the north-facing slope (MNS), and the base of the north-facing slope (BNS). Four plots (10×10 cm) were randomly selected at each of positions, and at each plot soil was collected from the 0-30 cm soil layer in each position. The soil mesofauna was extracted using Tullgren funnel extractors and then counted under a microscope (OLYMPUS SZX 16).

The Shannon-Wiener index was used to analyze the diversity of the soil mesofauna. One-way ANOVA and LSD were employed to test the differences of the density, richness and diversity of soil mesofauna among the different positions and different months.

Results and Discussion

Composition of soil mesofauna on the fixed sand dunes: 29 different groups and 1530 individuals were captured. The mean density was 2536.67 ind·m^{-2}. Oribatida and Actinedida, which accounted for76.87% of the total densities, were the dominant groups. The other relatively abundant taxa were Gamasida, Hypogastruridae, Pseudachorutinae, Entomobryidae and Psocoptera, collectively accounting for 16.96%. These groups were the main groups of the fixed sand dunes.

The statistical results showed that the densities on the BSS and MNS were significantly higher than those on the MSS and TS (p<0.05), while the richness on the TS was significantly lower than those on the BSS and MNS (p<0.05). Therefore, the topographic position had a clear influence on the distribution of the soil mesofauna.

Table 1: Soil faunal composition under different topographic positions in fixed sand dunes on the Songnen Grasslands

	BSS	MSS	TS	MNS	BNS	Mean density	%
Oribatida	2166.67	858.33	741.67	2466.67	1791.67	1605	63.27
Gamasida	258.33	175	41.67	450	283.33	241.67	9.53
Actinedida	966.67	125	150	300	183.33	345	13.60
Hypogastruridae	116.67	8.33	33.33	141.67	25	65	2.56
Isotomidae	8.33	8.33	33.33		8.33	11.67	0.46
Entomobryidae	33.33			116.67	8.33	31.67	1.25
Onychiuidae	8.33					1.67	0.07
Sminthuridae			8.33			1.67	0.07
Pseudachorutinae		33.33	150	8.33	83.33	55	2.17
Cerapotogonidae	25		33.33	25		16.67	0.66
Muscidae	25	25			16.67	13.33	0.53
Brachycera	8.33		16.67	8.33		6.67	0.26
Carabidae	8.33			25	16.67	10	0.39
Formicidae	8.33	50				11.67	0.46
Cydnidae	8.33	8.33			8.33	5	0.20
Staphylinidae	16.67			25	16.67	11.67	0.46
Pseudoscorpionida				16.67		3.33	0.13
Phlaeothripidae	41.67	25	16.67		25	21.67	0.85
Tenebrionidae	16.67	16.67			8.33	8.33	0.33
Anthocoridae	8.33					1.67	0.07
Scarabaeidae	8.33					1.67	0.07
Tenebrionidae larvae		25			8.33	6.67	0.26
Scarabaeidae larvae		16.67			8.33	5	0.20
Curculionidae larvae		8.33				1.67	0.07
Elateridae larvae		25				5	0.20
Carabidae larvae			8.33	25		6.67	0.26
Psocoptera	83.33	16.67	41.67	41.67		36.67	1.45
Coccomorpha		8.33		0		1.67	0.07
Noctuidae larvae				16.67		3.33	0.13
Total density($ind \cdot m^{-2}$)	3816.67	1433.33	1275	3666.67	2491.67	2536.67	
Group number	19	17	12	14	15	29	

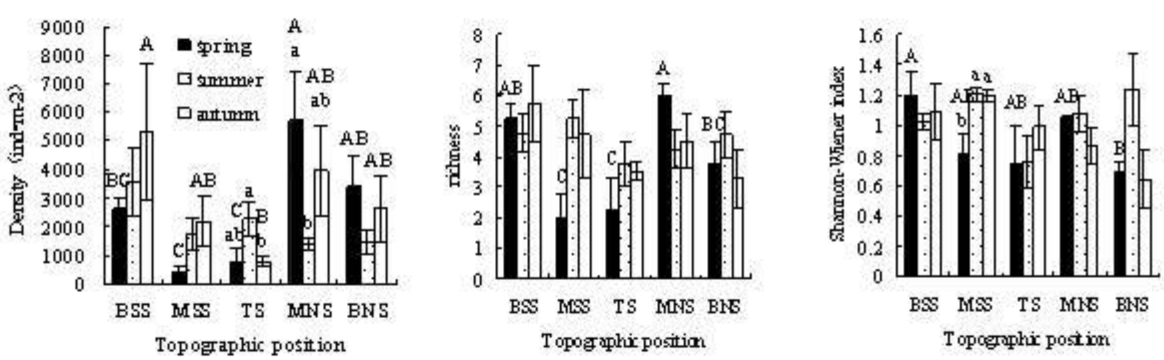

Fig.1: Density, richness and diversity of soil mesofauna on the different topographic positions on the fixed sand dunes on the Songnen Grasslands

Capital letters indicate the differences of the five topographic positions within same time period, while lower-case letters indicate the differences among the three seasons within the same topographic position at the $p<0.05$ level.

Dynamics of soil mesofauna on the different topographic positions: The densities on the MNS (*p*=0.002) and BNS (*p*=0.046) were significantly higher than those on the TS in the spring (Fig. 1). The density on the BSS was significantly higher than that on the TS (*p*=0.043). The soil faunal densities on the south-facing slope increased with the passing of time, with the lowest in the summer on the north-facing slope and the highest in the autumn on the top of the slope. The density on MNS in the spring was clearly higher than that in the summer (*p*=0.046); and the density on the TS in the summer was clearly higher than that in the autumn (*p*=0.043). The richness on the BSS was highest. In particular, the richness on the BSS in the spring was higher than that on the MSS (*p*=0.007) and TS (*p*=0.011). No significant difference of richness was found among the different time periods (*p*>0.05). The diversity on the BSS in the spring was higher than that on the BNS (*p*=0.035), and the diversity on the BNS in the spring was lower than that in the summer (*p*=0.014) and autumn (*p*=0.014).

The results of this study showed that the topographic position had a clear effect on the distribution of the soil mesofauna. Topography can control the redistribution of the hydrothermal conditions, thus indirectly affecting the composition and distribution of soil fauna. The main performances are the elevation, which can control the temperature, and the slope direction and gradient, which have an effect on the solar radiation distribution (Sadaka, 2003). On a small scale, the topographic position can redistribute the soil nutrients and moisture, causing a change in the distribution pattern of the soil fauna (Xin, *et al.*, 2013; Anahí, *et al.*, 2014). Therefore, the difference of the topographic position resulted in the difference of distribution pattern of soil mesofauna at the study site. The diversity of soil mesofauna showed significant differences among the topographic positions on the fixed sand dunes, which clearly reflected the characteristics of the topographic position. The temperature, moisture and vegetation had significant effects on soil faunal diversity (Yin, *et al.*, 2010; Wenninger and Inouye, 2008). The habitat conditions of BSS were superior to those of BNS, resulting in the higher diversity. Due to the fact that the elevation difference between MSS and MNS was not large, and the difference of ecological factors was not significant, the difference of diversity was not substantial.

Conclusion

29 different groups, with a total 1530 individuals, were captured. The mean density was 2536.67 ind·m^{-2}, and the soil faunal densities on the BSS and MNS were significantly higher than those on the MSS and TS. The soil faunal densities on the south-facing slope increased with the passing of time, with the lowest in the summer on the north-facing slope and the highest in the autumn on the TS. The richness of the BSS and MNS was significantly higher than those of the TS. The spatial variation in terms of diversity differed among the positions. Therefore, the distribution and diversity of soil mesofauna on the fixed sand dunes were significant affected by the topographic position.

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Acknowledgement

This study is supported by the National Natural Science Foundation of China (41471211, 40871120).