第 20 卷第 6 期 生 态 学 报 Vol. 20, No. 6
2000 年 11 月 ACTA ECOLOGICA SINICA Nov., 2000

长白山北坡暗针叶林群落特征

郝占庆[1], 吴 钢[2], 邓红兵[1], 李 静[2], 曹 伟[1]
(1. 中国科学院沈阳应用生态研究所, 沈阳 110015; 2. 中国科学院生态环境研究中心, 北京 100085)

摘要: 长白山北坡的暗针叶林带分布海拔为 1100～1850m, 在野外调查的基础上, 对暗针叶林沿海拔梯度物种组成的分布格局进行了研究。文中用 α 和 β 多样性指数来度量森林群落的多样性, 用群落系数(本质上是一种 β 多样性指数)来度量不同群落或样地间的相似性, 同时用欧氏距离和 Ward 法对所有样地进行了聚类分析。研究结果表明主要树种云杉和冷杉在整个暗针叶林带均有分布, 而伴生树种和多数灌木出现于一定海拔范围内; 沿海拔梯度物种数变化小而物种组成变化大则表明长白山暗针叶林丰富的生境多样性。聚类分析可将长白山暗针叶林分成 2 或 3 种类型, 这与通过对不同海拔公路同侧样方的群落系数的分析所得结果类似。

关键词: 暗针叶林; 群落; 多样性; 长白山

Community characteristics of dark coniferous forest on north slope of Changbai Mountain

HAO Zhan-Qing[1], WU Gang[2], DENG Hong-Bing[1], LI Jing[2], CAO Wei[1] (1. *Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang* 110015, *China*; 2. *Department of Systems Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing* 100085, *China*)

Abstract: The dark coniferous forest was distributed between 1100m and 1850m in the subalpine of Changbai Mountain, and the distribution pattern of species composition along elevation gradient in dark coniferous forest on north slope was sampled and analyzed in this research. The α and β diversity were used to measure the community diversity of the forests, and community coefficient, which was one kind of β diversity in essence, was used to analyze the similarity of species composition between the communities or plots. Based on these analyses, communities were classified according to Euclidean distance by Ward's method. The results showed that the dominant tree species *Picea jezoensis* and *Abies nephrolepis* were distributed nearly over the whole transect, and the companion trees and most of shrubs were found in certain fragments respectively. The total number of species of the plot varied slightly, but species composition among the plots varied greatly along with the elevation variation. This trend reflected the high habitat diversity of this forest zone. The dark coniferous forest could be divided into 2 or 3 types by the classification analysis, and this result was similar to that coming from calculating community coefficient between plots in the same side with different elevations.

Key words: dark coniferous forest; comunity; diversity; Changbai Mountain
文章编号: 1000-0933(2000)06-0916-06 **中图分类号**: Q948 **文献标识码**: A

Introduction Changbai Mountain is the highest mountain in northeastern China. It has the typical vertical spectra with five vegetation zones, including 4 forest and one tundra zones. A total of 1365 vascular plant species has been reported which includes 1260 species of seed plants. Some of them are relic species,

Foundation item: The project was supported by National Natural Science Foundation of China (No. 39770139) and Foundation of Opened Research Station of Changbai Mountain Forest Ecosystem
Recived date: 1999-09-02; **Accepted date**: 2000-06-10

Brief introduction of author: HAO Zhan-Qing (1964～), Shanxi, Xiyang, ph. D, professor. Forest Ecology; Biodiversity.

and 96 species are pteridophytes.

The dark coniferous forest, which distributed between 1100m and 1850m in the subalpine of Changbai Mountain[1], was the major type of forest in this area and covered nearly 60% of the reserve. Since the dark coniferous forest distributed along nearly 700m elevation gradients, the structure and species composition varied obviously. Many studies[1~3] have been done on the vegetation composition, but more detailed information is needed for understanding the vegetation type variation and the species diversity pattern, because much of the reported data is insufficient for describing the community features. The aim of this study is to outline the composition, structure and gradient relationship of plant communities in the forest by investigating the communities at different elevations.

1 Study area and methods

The plots were set inside the Biosphere Reserve of Changbai Mountain, which is situated on the border between China and North Korea. The mean annual temperature is 3.3℃, with the maximum of 32.3℃ and the minimum of −37.6℃. The annual precipitation is 671.9mm and the relative humidity is 66%. The hottest month is August with the mean maximum temperature of 20.5℃, and the coldest month is January, with the mean minimum temperature of −16.5℃. The distribution of rainfall over the year is unequal. A relatively wet season occurs from June to August, while a relatively dry season occurs from September to May. The climate is characterized by low temperature, high precipitation, and strong wind.

Since all the plots were set inside the reserve, the vegetation has remained pristine with almost no human disturbance. Fieldwork was carried out in the summer of 1997. On both sides along the road, 12 plots were investigated at the elevation 1200 m、1300 m、1400 m、1500 m、1600 m、1700 m respectively, and the plot sizes were 20m×20m. In each plot, five sub-plots with the size of 2m×2m were set for shrub and herb species investigation. Tree species were recorded if $DBH > 8.0$cm. For shrub and herb layer, the species, height, coverage and density were measured or recorded. Data processing were done by using software such as EXCEL, SYSTAT, and STATISTICA.

2 Results

2.1 Physiognomy and vegetation structure

The coniferous forest was dominated by evergreen conifer species such as *Picea koraiensis*, *P. jezoensis*, and *Abies nephrolepis* with the height of 22～30 m. In winter it remains relatively pure green. Above the dominant canopy layer, there were some individuals of *Larix olgensis* sparsely dotted in the community, stood much higher than the dominant canopy layer, and it looked like *Larix olgensis*-dominated. However, contrary to *P. jezoensis* and *A. nephrolepis*, this species had no saplings or seedlings on the ground. At the lower elevation, *Pinus koraiensis* was mixed with the dominant species. The broad-leaved components in this zone were mainly sub-canopy or high shrub species such as *Acer ukurunduense*, *A. tegmentosum*, *A. tschonoskii*, *A. mono*, *Betula costata*, *B. ermanii*, and *Sorbus pohuashanensis* with very low dominance.

The trunks were covered by mosses, and it indicated the wetness and darkness of the environment that heavily restricted the species richness of undergrowth. The ground vegetation consisting of herbs and small-sized shrubs was very poor with the coverage of less than 40%, while that of the bryophyte layer was more than 90%. The seedlings of *A. nephrolepis* and *P. jezoensis* were tremendous. It was extremely dark under the canopy since the forest had a quite high density and a high crown closure. Referring to the light condition, it was called dark coniferous forest.

The shrub layer was almost absent due to the highly closed canopy, and there sparsely distributed individuals on the ground, such as *Acer ukurunduense*, *A. tschonoskii*, *A. tegmentosum*. Some shrubs with less than 15 cm high presented a comparatively high density but lower coverage, total less than 20%, such as *Ramischia secunda*, *Chimaphila japonica*, *Linnea borealis* and so on, and these species can be considered as the characters or indicators for the coniferous forest zone.

The floristic composition of the herbaceous layer was poor, and the average height was less than 20cm with total coverage of less than 40%. The dominant species were *Maianthemum dilatatum*, and some ferns. Mosses formed a unique layer with a depth of about 10cm and the coverage of nearly 100%.

2.2 Community diversity

Community diversity include α diversity and β diversity[4~7] i.e. in-diversity and interdiversity of the communities. α diversity is an important index to describe the community composition and structure. The measurement of α diversity generally includes 4 indices. Among them, the species richness, especially the number of species very common and simple. It is very practical for measuring the diversity.

Table 1 lists the numbers, of species, is in 12 plots. Variance analysis of the species showed that, for tree species, there were significant differences among the plots at different elevations ($F=11.5>5.05=F_{0.05(5,5)}$), but there were no significant differences between the plots at same elevations ($F=3.75<6.61=F_{0.05(1,5)}$). For shrubs, significant differences existed among the plots at different elevations ($F=20.6>11.0=F_{0.01(5,5)}$) and different plots at same elevation. For herbs, it showed the same trend as trees, i.e. there were significant differences among the plots at different elevations ($F=8.43>5.05=F_{0.05(5,5)}$), but there were no significant differences between the plots at same elevations ($F=1.25<6.61=F_{0.05(1,5)}$). For all the species in the plots, there were no significant differences among the plots at different elevation ($F=2.60<5.05=F_{0.05(5,5)}$) and between the plots at same elevations ($F=5.37<6.61=F_{0.05(1,5)}$).

Table 1 Species number in 12 plots

Elevation (m)	West side of the road Number of species				East side of the road Number of species			
	Tree	Shrub	Herb	Total	Tree	Shrub	Herb	Total
1200	11	12	7	30	10	6	8	24
1300	11	10	9	30	10	9	14	33
1400	6	10	28	44	8	4	23	35
1500	7	6	18	31	8	6	16	30
1600	8	9	24	41	6	6	15	27
1700	5	5	20	30	4	1	18	23

β diversity[8,9] is essentially a measure of how different (or similar) a range of habitats or samples are in terms of variety of species found in them. One common approach to β diversity is to look at how species diversity changes along a gradient. Another way of viewing β diversity is to compare the species composition of different communities. Cody index was useful in measuring the change of the community composition along habitat gradient, and it is easy to calculate by the number of new species added and some species lost along a transect.

$$\beta = (g(H) + 1(H))/2 \qquad [1]$$

Where $g(H)$ is the number of species gained along the habitat transect and $1(H)$ is the number of species lost along the same transect.

Fig. 1 is the Cody index values of community in different elevation. It showed that the Cody index of tree and shrub kept a low value, and the value of shrub was a little higher than that of tree. Cody index of herb layer varied greatly with the change of elevation. Variation of Cody index for all the species showed the same trend as herbs. Variance analysis showed that there was no significant difference among the plots at different elevations and between the plots at same elevations for tree, shrub, and herb layers. But for all the species of tree, shrub and herb layers, Cody index was significant difference among the plots at different elevations ($F=19.36>16.0=F_{0.01(4,4)}$) and between the plots at same elevations ($F=22.01<21.2=F_{0.01(1,4)}$).

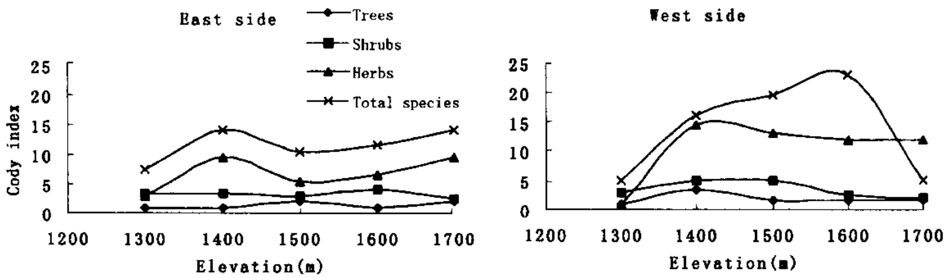

Fig. 1　Cody index of communities in different elevations

Contrary to the α diversity, β diversity of communities varied greatly with the elevation. This indicated that the total numbers of species of the plot varied slightly, but species composition among the plots varied greatly with the elevation variation. This trend reflected the high habitat diversity of the forest zone.

2.3　Community coefficient

Community coefficient concerned the similarity of species composition between the communities or plots. A vast range of similarity indices exists. Jaccard index and SΦrenson index[10] are widely used, and SΦrensen index can be calculated by formula[2].

$$CC=\frac{2a}{b+c} \qquad [2]$$

Where a means the number of species found in both site A and site B, b means the number of species in site A, and c means the number of species in site B.

Fig. 2 is the community coefficient of two plots beside the road at the same elevation. All these values are higher than 0.5, which indicate that it is much similar in species composition between two plots at the same elevation, especially at the elevation 1200m and 1500m.

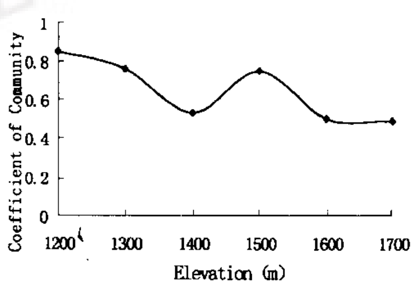

Fig. 2　Community coefficient between two plots with the same elevation

Fig. 3 is the community coefficient between two neighborhood plots on the same side of the road at the different elevation. It indicates the influences of elevation on species composition. The community coefficients between two plots at 1200 m and 1300 m are the highest, so the forest communities at 1200m and 1300m can be classified into the same type. The community coefficients between plots at 1300m and 1400m are lower, and they are both inflexions of the curves in Fig. 3, so the forest communities at the elevation higher than 1400m and lower than 1300m should be classified into two types.

Fig. 3 just shows the difference between two neighborhood plots on the same side of the road at the different elevation. For the plots of no-neighborhood, their difference can be calculated by using geo-statistics. The result could be seen in fig. 4.

Fig. 4 indicates that average community coefficient between plots with same elevation difference decreased with the increase of elevation difference on the west side of the road. But on the east side of the road, the decreasing rate of the community coefficient is different between elevation difference less and greater than 300m. This maybe means elevation differences less and greater than 300m are two different sampling scales.

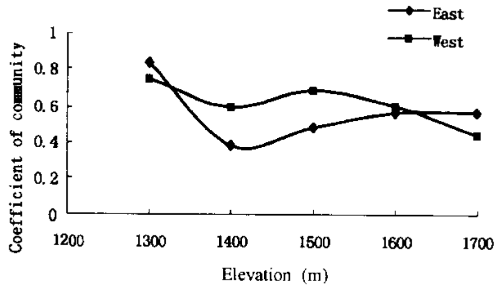

Fig. 3 Community coefficient between plots on the same side with different elevations

2.4 Community classification

Fig. 5 is the tree diagram for 12 plots with Ward's method and Euclidean distances, and $q1$ meant the plot of 1200m and on the east side, $q2$ meant the plot of 1200m and on the west side, and so on.

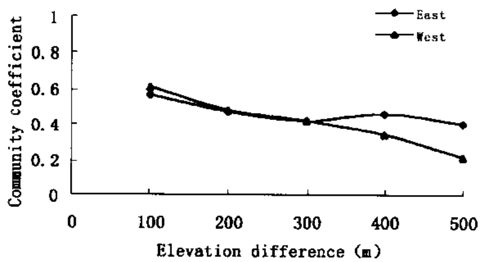

Fig. 4 Average community coefficient beween plots with same elevation difference

Fig. 5 shows that the classification results are greatly related to the elevation. The plots which were located at the elevation lower than 1400m can be classified into one type and those higher than 1400m can be another large type, which can be divided into two types by the elevation 1600m. In addition, two methods (Ward's method and single linkage method) and two distances (Euclidean distance and community dissimilarity coefficient) were used to do the classification and the results were a little different. It means that different distance has little influence on the classification results, but different methods has great influence on the classification results.

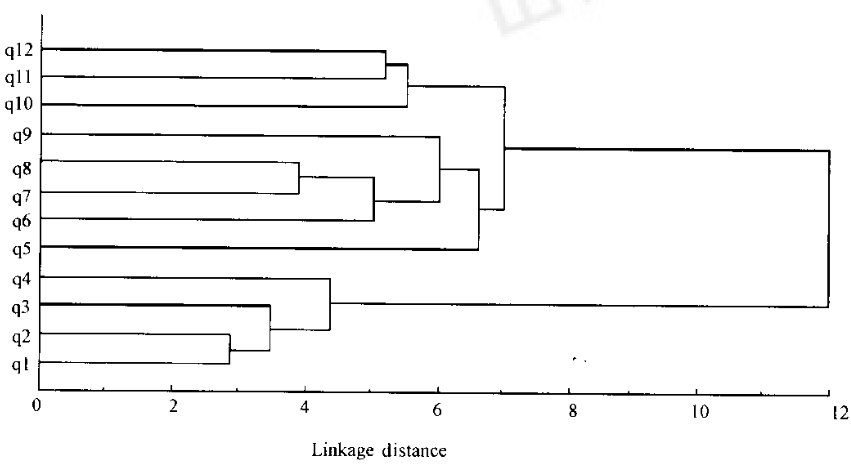

Fig. 5 Tree diagram for 12 plots with Ward's method and Euclidean distances

3 Discussion

Habitat diversity caused by elevation changes resulted in a high diversity on both the α and β diversity. Contrary to the α diversity, β diversity of communities varied greatly with the elevation. This indicated that the total numbers of species of the plot varied slightly, but species composition among the plots varied greatly with the elevation variation. This trend reflected the high habitat diversity of the forest zone.

Dark coniferous forest distributed from 1100m to nearly 1800m. The environment changed gradually with the elevation variation so that the community characteristics showed up an obvious difference along the slope. Dark coniferous forest could be classified into different communities according to the degrees of species diversity variation, and the results was similar to that of classification analysis.

References

[1] Li Wenhua, Deng Kunmei, Shao Bin, *et al*. The study on basic feature and community structure in dark coniferous forest of Changbai Mountain. *Research of Forest Ecosystem*, 1994, (7): 1～15.

[2] Wang Zhan, Xu Zhenbang, Li Xin, *et al*. The main forest types and their features of community structure in northern slope of Changbai Mountain(1). *Research of Forest Ecosystem*, 1980, (1): 25～42.

[3] Chen Lingzhi. The preliminary study on the structure of *Picea jezoensis* forest in southwestern slope of Changbai Mountain. *Plant Ecology and Geobotany Collection*, 1963, **1**(1～2): 69～80.

[4] Biodiversity Committee of Chinese Academy of Science. *Principle and Methodology of Biodiversity Study*. Beijing: Chinese Science and Technology Press, 1994.

[5] Magurran A E. *Ecological diversity and its measurement*. Princeton Univ. Press. 1988.

[6] Ye Wanhui, Ma Keping, Ma Keming, *et al*. Study on plant community diversity in Donglingshan Mountain, Beijing China. Ⅸ. The influence on α diversity by scale variation. *Acta Ecologica Sinica*, 1998, **18**(1): 10～18.

[7] Whittaker R H. Evolution and measurement of species diversity. *Taxon*, 1972, **21**: 213～251.

[8] Cody M L. Towards a theory of continental species diversity bird distribution over Mediterranean habitat gradients. In: Cody M. L. and Diamond M. J. Eds. *Ecology and evolution of communities*. Harvard Univ. Press, Cambridge. 1975.

[9] Ma Keming, Ye Wanhui, Sang Weiguo, *et al*. Study on plant community diversity in Donglingshan Mountain, Beijing China. X. β diversity and fractal analysis on transect on different scales. *Acta Ecologica Sinica*, 1998, **17**(6): 626～634.

[10] Wang Bosun, Yu Shixiao, Peng Shaolin, *et al*. Eds. *Booklet of plant community experiment*. Guangdong Higher Education Press, 1996.