Acta Ecologica Sinica 29 (2009) 272–277

Contents lists available at ScienceDirect

Acta Ecologica Sinica

journal homepage: www.elsevier.com/locate/chnaes

Latitudinal changes in species diversity of permafrost wetland plant communities in Great Xing'an Mountain valleys of Northeast China

Ju Sun [a,b,1], Xiu-Zhen Li [a,*], Xian-Wei Wang [a,b], Jiu-Jun Lv [a,b], Zong-Mei Li [a,b], Yuan-Man Hu [a]

[a] Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110016, China
[b] Graduate University of Chinese Academy of Sciences, Beijing 100049, China

ARTICLE INFO

Keywords:
Great Xing'an Mountains
Permafrost
Wetland
Species diversity
Latitudinal gradient

ABSTRACT

Studying the changes of species diversity in plant communities along latitude gradients is important to discover the correlation between biodiversity and environmental factors. Along the main ridges of the Great Xing'an Mountains, 12 natural permafrost wetlands in the valleys were investigated from north to south. Latitudinal changes in species diversity were analyzed with regressive analysis. About 150 plant species were recorded and were found to be in the 12 permafrost wetland plant communities. Most plants belong to the Compositae or Gramineae. The number of family, genus and species increased significantly in the herb layer with decreasing latitude ($P < 0.01$), but decreased significantly in the shrub layer ($P < 0.01$). Species composition and the orders of dominant species in the plant communities by importance value changed along latitude. Latitudinal changes of α-diversity in permafrost wetland plant communities were different in the herb and shrub layers. With decreasing latitude, species richness and species diversity increased in the herb layer; but decreased in the shrub layer. The opposite patterns were found for species dominance. Species evenness in the shrub layer decreased with decreasing latitude. ß-diversity in the herb and shrub layers decreased first, and then increased, and finally decreased with increasing latitude. Species composition in the herb layer was similar among the plots at higher latitudes.

1. Introduction

The changes of species diversity in plant communities along environmental gradients are regarded as the changes of plant species diversity along ecological factor gradients at community levels [1]. It is one of the most important parts in the studies on biodiversity and is helpful to discover the correlations between biodiversity and ecological factors. Nowadays, the studies on the changes of species diversity along environmental gradients have focused mainly on latitudinal gradient, water gradient, altitudinal gradient, soil gradient and succession gradient [2–7]. Latitudinal gradient contains gradient effects of many environmental factors, such as water and heat factors. To study latitudinal patterns has important meanings to discover the correlations between biodiversity and ecological factors. At big scales, it is well known that species richness and species diversity in plant community decrease with increasing latitude from equator to the two poles [8,9]. However, at region scales, latitudinal patterns in species diversity may be different for plant species with different growth forms, i.e. arbor, shrub and herbage [10,11]. It needs more studies. Wetland vegetation is no-zonal vegetation. However, being influenced by climate wetland vegetation changed partially along longitude and latitude, and distribution of vegetation types had obvious differences from north to south, and east to west [12]. Nowadays, quantity analysis on species diversity in wetland plant communities along latitudinal gradients has few reports [7].

The Great Xing'an Mountains stand on the northeast of China and they have the only typical zonal permafrost in China. Lying on the southern edge of Eurasia permafrost, the permafrost in this area is sensitive to climatic change, and it is degenerating from south to north in apparent response to climatic warming [13–16]. Influenced by terrain and climatic factors at region scales, permafrost and wetlands in the valleys of the Great Xing'an Mountains coexisted usually [17]. Due to the cold meteorological condition at high latitudes, the vegetation in this area is sensitive and can quickly respond to climate warming. Therefore, the permafrost wetlands in the Great Xing'an Mountain valleys are regarded as the key area in response to climatic changes, and they can foretell much about global warming. Studies on species diversity in permafrost wetland plant communities are few in china [18]. In this study, we analyzed the change patterns in species diversity in permafrost wetland plant communities in the Great Xing'an Mountain valleys along latitudinal gradients. It is helpful to understand the correlations between biodiversity and ecological factors, and

* Corresponding author. Tel.: +86 24 8808 78 83; fax: +86 24 8397 03 00.
E-mail address: lixz@iae.ac.cn (X.-Z. Li).
1 Ph.D. candidate, mainly engaged in climate change and wetland ecology.

1872-2032/$ - see front matter © 2009 Ecological Society of China. Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.chnaes.2009.09.003

improve the studies on degeneration of permafrost and permafrost wetlands, and changes of permafrost wetland vegetation in response to global warming.

2. Methods

2.1. Study sites

The Great Xing'an Mountains stand on the northeast of China and have the virgin forest dominated by *Larix gmelinii*. The study sites are located from 53°12′10″N and 122°59′59″E to 48°49′36″N and 120°47′59″E. The altitude varies between 463 and 787 m a.s.l. The study area is characterized by a terrestrial monsoon climate of the Cool Temperate Zone with a long and severe winter. Average annual temperature is around −3 to 0 °C. Average annual precipitation is around 300–500 mm, more than 80% of which occurs between June and August. Average annual frost-free period is between 90 and 110 days. The study sites were set on the permafrost wetlands in the valleys. The natural valleys are broad, plain. The underground permafrost becomes natural waterproof layer. Due to impeded drainage in valleys, high water table and the underground permafrost, surface flow neither flow off nor filter into soil, which results in numerous permafrost wetlands in the Great Xing'an Mountain valleys [19]. The soils are meadow and marsh soils, which are loose and rich in organic matter and water [20]. The main species in the permafrost wetlands are *L. gmelinii*, *Betula platyphylla*, *B. fruticosa*, *Rhododendron parvifolium*, *Ledum palustre* var. *angustum*, *Salix rosmarinifolia*, *Vaccinium uliginosum*, *Carex* spp. and *Sphagnum* spp.

2.2. Field sampling

The ecological survey was performed during three weeks between July and August in 2007, when plant cover is at its maximum, and most species are still present (some ephemeral species may have been missed). The transect was set on the western slope of the Great Xing'an Mountains from north to south by way of Mohe, Tuqiang, Chaoman, Mangui, A Longshan, Jinhe, Tu Lihe, Yuanlin, Ya Keshi, Wu Nuer. We chose the 12 permafrost wetlands in plain valleys with similar slope aspects as plots. Herbages were sampled and counted in 13–18 quadrates of 2×2 m^2 and shrubs in 10 quadrates of 4×4 m^2 in each plot. The number of quadrates would be needed to capture at least 90% of the species in each plot. Scientific name, number, height, crown width, and frequency of plant species in each quadrate were recorded. Arbor with either $\leqslant$2.5 cm diameter at breast height (dbh) or $\leqslant$2 m height was recorded and analyzed as shrub. Latitude, longitude and altitude in each plot were measured using GPS.

2.3. Data analysis

The number of family, genus and species in plant communities, the Gleason index d_{Gl} (species richness), the Shannon–Wiener index H' (species diversity), the Simpson index (species dominance) D, and the Pielou index E (species evenness) were selected to examine α-diversity in the 12 plots [21–24].

The importance value (IV) of species was calculated using the following formulae:

IV shrub = (relative density + relative height + relative coverage) × 100/3
IV herbage = (relative height + relative coverage + relative frequency) × 100/3
Gleason index: $d_{Gl} = S/\ln A$
Shannon–Wiener index: $H' = -\Sigma P_i \ln P_i$
Pielou index: $E = H'/\ln S$
Simpson index: $D = \Sigma Pi^2$

where P_i is the relative importance value of the i-th species; S is the number of species in each quadrate; and A is the area of each quadrate.

We also used the Dissimilar coefficient and Cody index to examine ß-diversity among the 12 plots.

Dissimilar coefficient: $CD = 1 - 2c/(a + b)$
Cody index: $ß_T = (a + b - 2c)/2$

where c is shared species; a is the number of species at one plot; and b is the number of species at another plot.

To analyze latitudinal patterns in species diversity, correlation between diversity indices (i.e., the number of family, genus and species; d_{Gl}, H', d and E) and latitude was tested with ANOVA for herbages and shrubs. Data were analyzed using Microsoft Office Excel 2003.

3. Results

3.1. Latitudinal changes in species composition

About 150 species were identified in the 12 plots, the most of which belong to the Frigid and Temperate Zone, and few belong to the Temperate Zone. The ferns consisted of one family, two genus, and three species; the gymnosperms consisted of one family, one genus, and one species; and the seed plants consisted of 37 family, 101 genus, and 146 species. About 21 species belonged to Compositae, and 14 species belonged to Gramineae, both of which were 23.3% in the total of the species in the 12 plots. Other richest families were Rosaceae (9), Leguminosae (8), Ranunculaceae (8), Caryophyllaceae (8), Scrophulariaceae (8), Cyperaceae (6), Umbelliferae (6).

In the 12 plots, the number of family, genus and species was 4–25, 5–53 and 5–66 in the herb layer, and 1–7, 1–11 and 3–12 in the shrub layer. Species richness in the herb layer was more than in the shrub layer. Data on the numbers of family, genus and species were analyzed by simple polynomial regression against latitude (Fig. 1). The number of family, genus and species decreased significantly linearly in the herb layer ($P < 0.01$) with increasing latitude, but increased significantly linearly in the shrub layer ($P < 0.01$). This relationship explained 55.69%, 64.86% and 69.31% of the variance of the number of family, genus and species in the herb layer, and 65.55%, 73.08% and 67.94% in the shrub layer, respectively.

The main plant community types were *B. fruticosa* – *Carex* spp. comm. and *S. siuzevii* – *Carex* spp. comm. in the 12 plots. Top five of the plant species by importance value were showed in Table 1. From plots 1 to 12, dominant species with the biggest importance value in the herb layer changed from *Eriophorum vaginatum*, *Carex globularis*, *Calamagrostis langsdorffii*, *C. rhynchophysa* to *C. schmidtii*; dominant species in the shrub layer changed with decreasing latitude from *B. fruticosa*, *L. palustre* var. *angustum* and *V. uliginosum* to *B. fruticosa*, *Spiraea salicifolia* and *Potentilla fruticosa*, and then to *B. fruticosa*, *S. rosmarinifolia* and *S. pentandra*, and finally to *S. siuzevii* and *S. rorida*.

3.2. Latitudinal changes in species richness

For the species with different growth forms, the patterns in species richness in the permafrost wetland plant communities in the Great Xing'an Mountain valleys were different along latitude. Species richness in the herb layer decreased significantly ($P < 0.01$)