The effects of the disturbance of tourism activities on *Rhododendron chrysanthum* in Changbai Mountain Reserve

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Abstract. The effects of tourism disturbance on the community structure composition and variation of species diversity of *Rhododendron chrysanthum* population in the alpine tundra of Changbai Mountain were studied to provide reference for better protection of the ecological environment of Changbai Mountain. At different altitudes in the alpine tundra, the regions close to and far from the tourist routes were selected as the study sites, and the typical *Rhododendron chrysanthum* community in the alpine tundra was selected as the research object. The results showed that tourism disturbance would affect the plant growth of *Rhododendron chrysanthum* community. The average height, relative coverage and relative density of *Rhododendron chrysanthum* decreased, leading to the decrease of the important value and dominance of *Rhododendron chrysanthum* in the whole community. The higher the intensity of tourism disturbance was, the more significant the characteristics of *Rhododendron chrysanthum* were. In addition, the variation of the biodiversity of *Rhododendron chrysanthum* community under different tourist disturbance intensity in the middle and low altitude areas of Changbai Mountain alpine tundra was consistent with the theory of “moderate disturbance hypothesis”. At high altitude, Shannon-Wiener species diversity index, Pielou evenness index and Simpson dominance index of *Rhododendron chrysanthum* community all decreased with the decrease of disturbance intensity. Therefore, in order to achieve a better development of tourism in Changbai Mountain, some measures should be taken to reduce the impact of the disturbance intensity of tourism activities on the plant community in the scenic area.

1. Introduction

Tourism disturbance is one of the main disturbance forms of human activities to the ecosystem of scenic area. With the development of tourism in recent years, the number of tourists received by Changbai Mountain scenic area has increased year by year, and the tourism of Changbai Mountain has developed rapidly. In recent years, the ecological role of tourism disturbance has been widely emphasized by domestic and foreign scholars. In 2013, Qu Yanan reported the effect of tourism activities on the vegetation of Yunqiu Mountain and believed that tourism activities have a greater impact on the herbaceous plants of Yunqiu Mountain. With the development of tourism, this trend will gradually expand and may even cause certain species to disappear in this area [1]. Zhang Guiping et al. analyzed the effects of tourism disturbance on plant diversity in Lishan subalpine meadow and concluded that the relative coverage, relative height and relative density of dominant species in the
community would increase with the increase of the trail distance, and the associated plants would change in the opposite direction [2]. Tang Jianchao, Beatrice E et al. studied the disturbance of tourism activities on ecological environment in different aspects [3-5]. Many domestic studies have shown that tourism activities have many negative effects on the diversity of forest ecosystems.

In the alpine tundra of Changbai Mountain, due to the emergence of the isolated mountain, the winter is cold and long, and the summer is cool and short. Combined with the topographic factor, a sensitive and fragile tundra ecosystem is formed, which consists of stunted plants such as small shrubs, mosses and lichens [6]. Rhododendron chrysanthum is a typical evergreen shrub in the alpine tundra of Changbai Mountain, which has been listed as a national rare and endangered plant[7]. Therefore, as an important form of disturbance affecting Rhododendron chrysanthum community, the effect of tourist disturbance on the Rhododendron chrysanthum community in the alpine tundra is worth studying. This paper systematically analyzed the response degree of Rhododendron chrysanthum population to tourism disturbance from its growth state and community diversity, in order to provide reference for the protection of Rhododendron chrysanthum population and the management of Changbai Mountain Nature Reserve scenic area, and especially to provide decision support for the planning and construction of the trail.

2. Research Area and Research Method

2.1. Overview of the Research Area
The research area is located in the Betula ermanii-tundra transition zone with an altitude of 1900-2150m and the alpine tundra with an altitude of over 2150m on the northern slope of Changbai Mountain. The zonal climate of this area belongs to the humid subalpine climate. The winter is cold and windy, and the summer is cool and warm. The annual average temperature is low and the growing season is short[8].

2.2. Sampling plot setting and investigation
In order to study the effect of tourism disturbance on plant community structure and species diversity in the scenic area of Changbai Mountain Nature Reserve, samples were set at different altitudes from July to September according to the actual conditions such as community type, disturbance degree and altitude of Rhododendron chrysanthum population. According to the ratio of plant lodging and bare land area, tourism disturbance could be divided into three grades, no disturbance (almost no human disturbance, the plant lodging rate of less than 10%), light disturbance (light human disturbance, the plant lodging rate of 20 - 35%, the proportion of bare land area of 5 - 10%), moderate disturbance (obvious human trampling, the plant lodging rate of 20 - 35%, the proportion of bare land of more than 10%). Then, the effect of tourism disturbance on the growth of Rhododendron chrysanthum community was analyzed by means of individual indexes such as average height, average coverage, average species number, and comprehensive indexes such as species richness index, species diversity index and important value. In the actual survey, at an altitude of about 2300m, because tourists could not reach there, and Rhododendron chrysanthum mostly grew far away from the road, the Rhododendron chrysanthum at this altitude is well preserved, no obvious human trampling and no obvious medium disturbance in the area. The general situation of the sample plot is shown in Table 1.

| Study area | altitude/m | East longitude | North latitude | Community height/m | Community physiognomy | Overall relevance |
|------------|------------|----------------|----------------|-------------------|-----------------------|------------------|
| Low altitude area | 1900-2100 | 128°04’ | 42°03’ | 12.00 | Rhododendron chrysanthum-Betula ermanii forest. | |

Table 1. Description of the study sample plot.
Along the upper edge of the gully, *Rhododendron chrysanthum* is mostly distributed at the bottom of the interrupted gully.

| Altitude area          | Altitude (m) | Latitude (°) | Longitude (°) | Shrub Coverage |
|------------------------|--------------|--------------|---------------|----------------|
| Middle altitude area   | 2200-2400    | 42°02'       | 128°04'       | 0.30           |
| High altitude area     | 2500-2600    | 42°02'       | 128°04'       | 0.15           |

*Rhododendron chrysanthum* was distributed patchily, and the total shrub coverage was 85%.

2.3. Method of diversity determination

The Shannon-Wiener index, Simpson index and Pielou community evenness index, which are widely used in current studies were adopted for diversity analysis [7].

3. Results and Analysis

3.1. Effects of tourism on plant growth of *Rhododendron chrysanthum*

The overall development of aboveground vegetation is mainly concentrated on the community structure, and the most direct effect of *Rhododendron chrysanthum* community under different intensity of tourism disturbance is reflected in the vegetation height, coverage, important value and dominance of *Rhododendron chrysanthum*.

| Altitude (m) | Disturbance degree | Shrub layer species | Relative density | Average height (cm) | Relative coverage | Important value | Degree of dominance |
|--------------|---------------------|---------------------|------------------|---------------------|-------------------|----------------|---------------------|
| Low altitude area | No disturbance | 7                   | 0.573            | 28.063              | 0.922             | 0.601           | 0.493               |
| Middle-altitude area | Light disturbance | 7                   | 0.425            | 22.600              | 0.558             | 0.416           | 0.355               |
| High altitude area   | Moderate disturbance | 6                   | 0.223            | 18.900              | 0.407             | 0.294           | 0.267               |

- The higher the altitude, the less the number of individual plants and the simpler the structure of *Rhododendron chrysanthum* community. The variation of individual number and species in *Rhododendron chrysanthum* community was also different due to the different degree of disturbance at different altitude.
- As can be seen from Table 2, the species of shrub layer had little change under different intensity of tourism disturbance at different altitude, remaining about 7 species in 20m×20m quadrat. The average height of *Rhododendron chrysanthum* decreased with the increase of disturbance intensity.
- It can be seen from the data that the relative coverage of *Rhododendron chrysanthum* decreased greatly with the increase of disturbance intensity. The relative coverage of *Rhododendron chrysanthum* in the low altitude area decreased from 0.922 to 0.407 under the condition of no disturbance. The relative coverage of *Rhododendron chrysanthum* in the middle altitude area decreased from 0.657 under the condition of no disturbance to 0.331 under the condition of light disturbance. And the relative coverage of the *Rhododendron chrysanthum* in the high altitude area decreased from 0.630 to 0.274 under the condition of no disturbance.
- The change trend of relative density of Rhododendron chrysanthum is the same as that of vegetation height and coverage. With the increase of tourism distribution intensity, the relative density of *Rhododendron chrysanthum* in the whole community is also decreasing. Especially in the high altitude area, the distribution of Rhododendron chrysanthum has been very few. The relative density of
**Rhododendron chrysanthum** was 0.379 under the condition of no disturbance. While under the condition of moderate disturbance, the relative density of *Rhododendron chrysanthum* was reduced to 0.124, which was a relatively low proportion in the community.

### 3.2. Effects of tourism on species diversity of *Rhododendron chrysanthum* community

As can be seen from Table 3, no matter what kind of diversity index is used, the variation rules of high altitude areas are not consistent with those of low and middle altitude areas. Different intensity of tourism disturbance has different impacts on its biodiversity. In the low altitude and middle altitude areas, the Shannon-Wiener diversity index, Pielou evenness index and Simpson dominance index of *Rhododendron chrysanthum* community were the largest when the tourism disturbance was light. In the low altitude area, the Shannon-Wiener diversity index is light disturbance > no disturbance > moderate disturbance, the Pielou evenness index is light disturbance > moderate disturbance > no disturbance, and the Simpson dominance index is light disturbance > moderate disturbance > no disturbance.

| Table 3. Response of shrub layer characteristic index of *Rhododendron chrysanthum* community to tourism disturbance |
|---------------------------------------------------------------|
| altitude/m | Disturbance degree | Shannon-Wiener diversity index | Pielou evenness index | Simpson dominance index |
|------------|--------------------|-------------------------------|----------------------|------------------------|
| Low altitude | No disturbance | 1.222 | 0.628 | 0.890 |
|             | Light disturbance | 1.523 | 0.783 | 1.303 |
|             | Moderate disturbance | 1.191 | 0.665 | 1.012 |
| Middle altitude | No disturbance | 1.398 | 0.842 | 1.395 |
|             | Light disturbance | 1.724 | 0.886 | 1.638 |
| High altitude | Without disturbance | 1.650 | 0.848 | 1.435 |
|             | disturbance | 1.629 | 0.837 | 1.447 |
|             | Moderate disturbance | 1.482 | 0.826 | 1.274 |

In the high altitude area, the Shannon-Wiener diversity index, Pielou evenness index and Simpson dominance index of *Rhododendron chrysanthum* community decreased with the decrease of disturbance intensity.

### 4. Conclusion and Discussion

The positive and negative correlations between plant species were mainly caused by the ecological characteristics, ecological adaptability and ecological niche differentiation of species, reflecting the response of species to habitat differentiation or the existence of competition, and measuring the irrespecific correlation and the difference of plants’ reaction to environmental synthetic ecological factors to some extent.

- Tourism disturbance has obvious influence on the community structure of *Rhododendron chrysanthum* in different altitude areas. The average height, relative coverage and relative density of *Rhododendron chrysanthum* in the community decrease with the increase of disturbance intensity, leading to the decrease of the important value and dominance of *Rhododendron chrysanthum* in the whole community. Before any plant species is completely withdrawn from the community, the number of species gradually decreases and is gradually replaced by other species with stronger competitive ability. This process is a gradual process from quantitative change to qualitative change.

- Different intensity of tourism disturbance has different impacts on its biodiversity. The results showed that the species diversity was moderate and the evenness was the lowest in the middle and low altitude areas without tourism disturbance. With the increase of tourism disturbance intensity, species diversity increased obviously. At this time, the species are the most numerous and evenly distributed, with the highest diversity and evenness.
The stability of *Rhododendron chrysanthum* community was higher when there was no tourism disturbance in the middle and low altitude areas. Therefore, the variation of the biodiversity of *Rhododendron chrysanthum* community under different tourism disturbance intensity in the middle and low altitude areas of alpine tundra was consistent with the theory of “moderate disturbance hypothesis”. The results showed that the *Rhododendron chrysanthum* community in the high altitude area of the alpine tundra was restricted by the habitat and it had poor anti-interference ability. When subjected to varying degrees of tourism disturbance, the species and number in the community decreased obviously. The growth environment is harsh and the growth period is short. There will be no addition of other species.

The vulnerability of the ecosystem is different, and its ability to resist interference is also different. In the alpine tundra of Changbai Mountain, because of the influence of altitude, the average temperature is very low, and the frost-free period is very short. Some places are covered with snow all the year round. Such environment seriously inhibits the invasion of pioneer species. *Rhododendron chrysanthum* has always existed as the main species of the community. The leaves of *Rhododendron chrysanthum* are leathery and thick. Their internal tissues can be destroyed and die easily by tourist trampling, leading to the reduction of the overall population of *Rhododendron chrysanthum*. The great decrease of *Rhododendron chrysanthum* will inevitably lead to the disappearance of the lower layer lichen, the occurrence of large areas of bare land, and the aggravation of soil and water loss. Therefore, the tourists’ tramping on tundra should be strictly restricted.

**Acknowledgments**
This research was financially supported by Scientific and Technological Development Project of Jilin Province, China (Grant No.20180101017JC, No.20200201188JC).

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