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Effects of plateau pika (*Ochotona curzoniae*) on alpine meadow phytocoenosium and analysis of the strategy it uses to expand habitat

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ABSTRACT

High-density plateau pikas (*Ochotona curzoniae*) disturbance is one of the main causes of alpine meadow degradation. The response of phytocoenosium to the disturbance of plateau pika may reflect its habitat expanding strategy. We used quadrat sampling method to investigate vegetation height, coverage, and aboveground biomass of non-pika area (NA), transition area (TA), and pika-active area (AA) distributed continuously in alpine meadow located in Guoluo Tibetan Autonomous County of Qinghai Province in 2011 and 2012. The results showed that, from NA to AA (i) vegetation coverage, height, and above-ground biomass decreased ($P < 0.01$). (ii) While the number of plant species decreased from 41 to 30, and species diversity decreased significantly ($P < 0.05$), evenness of the alpine meadow showed no significant variations. (iii) Dominant species changed from grasses to weeds. (iv) While plants in TA showed no obvious difference in height between 2011 and 2012, coverage reduced significantly ($P < 0.05$). These results demonstrate that (i) plateau pikas disturbance on alpine meadow will change plant community structure and composition, directly leading to degeneration of alpine meadow. Additionally, (ii) plateau pikas expand their habitat by altering plant coverage firstly.

1. Introduction

Up till now, researches on degradation of alpine meadow focused on climate warming, over grazing and rodent damage. Degradation of alpine meadow caused by climate warming and over grazing provided more advantageous habitat for plateau pika, which in turn resulted in sharp increase of its population density. Burrowing habitat of plateau pikas damages the sod of alpine meadow, produces more bare patches, and exacerbates soil wind erosion and freeze thawing [1,2], then in reverse cause severely degradation of alpine meadow. Interaction between plateau pikas and phytocoenosium is one of the most important contents in researching the degradation of alpine meadow [2,3]. As the quick expanding of degradation area in alpine meadow, distribution of plateau pikas presents a continuous state correspondingly [4]. Then researches on relationship of plateau pikas and phytocoenosium all base on different degree of degradation [5–7]. However, interaction between phytocoenosium and closed plateau pika population caused by heterogeneity of regional phytocoenosium is rarely heard. The process of disturbance on phytocoenosium by closed plateau pika population during the habitat expanding can be seen as an epitome in space and time. Meanwhile, the response of phytocoenosium to the disturbance of plateau pikas may also reflects the strategy it takes in habitat expanding. More and more focus concentrate on spreading and migrating of plateau pikas as the degradation area of alpine meadow increases sharply. However, most researches focused on migration character and dispersal motivation itself [8–10], the remould on habitat during dispersal was always overlooked for the suitability of degraded alpine meadow. When plateau pikas expanding their habitat towards non-degraded areas, this remould effect will be amplified. At the same time, the amplification effect will be well revealed in the variation of phytocoenosium. This article aims at illuminate the detrimental effects of plateau pika and its habitat expanding strategy by analysing the influence on alpine meadow made by closed population, and provide theoretical supports for plateau pika control and restoration of degrade alpine meadow.

2. Materials and methods

2.1. Site description

The study was conducted in Dawu country of Qinghai province, China (34°11′N, 100°34′E, altitude 3980 m). The study area has a typical plateau continental climate, with mean annual temperature of −2.6 °C, and annual accumulated temperature above 0 °C is 914.3 °C. Annual precipitation is 513 mm with 85% of the precipitation occurs form May to September. No obvious four seasons, and no absolutely frost-free period.

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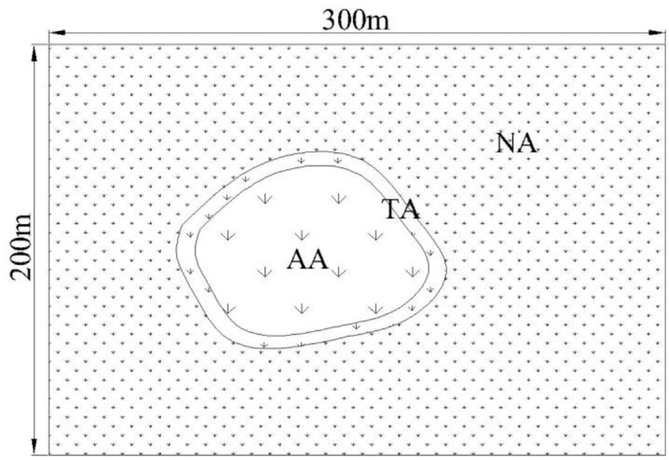

Fig. 1. Sample distribution diagrammatic sketch.

Once as artificial *Elymus nutans* meadow in the 1980th, the study area had experienced natural succession for >20 years after been abandoned with under grazing in winter. Now, the phytocoenosium type was *Elymus nutans* meadow, with main dominant species of *Elymus nutans* and *Poa pratensis*, common species include *Leontopodium pusillum*, *Ligularia virgaurea*, *Astragalus polycladus*, *Potentilla saundersiana* and *Lancea tibetica* etc.

2.2. Experimental design

To eradicate grazing disturbance, we enclosed the sampling area with woven wire fence of 200 m × 300 m, and divided it into 3 areas according to the occurrence frequency of plateau pika. Pika-active area (AA): plateau pikas appeared frequently. Transition area (TA): plateau pikas appeared occasionally. Non-pika area (NA): no plateau pikas was found. The total number of this plateau pika population was about 200, and their movement area (AA and TA) was about 1 hm^2 which was enclosed by NA (Fig. 1).

2.3. Plant community characteristics measurements

Sampling was carried out in the midmonth of August from 2011 to 2012. 10 quadrats of 0.5 m × 0.5 m were selected randomly in NA, TA and AA. Sampling position in TA was fixed in order to test the interannual changes. Coverage and aboveground biomass was measured in all 10 quadrats, and 5 of them were randomly chosen to measure the stem numbers, coverage, height and aboveground biomass of individual species. Coverage was measured by visual observation. The height is measured as mean value of 5 individuals chosen randomly, and if the number of one species is <5, then mean height of all individuals is used. Precision reaches to mm. Vegetation parts aboveground was clipped and classified by species, then oven dried to constant weight in 65 °C for 48 h. Precision reaches to 0.01 g.

2.4. Data analysis

Phytocoenosium parameters include Importance value: $IV = (RD + RC + RB + RH) / 4$. RD, RC, RB and RH stands for relative density, relative coverage, relative biomass respectively. Margalef richness index: $R = (S - 1)/ \ln N$. S and N stands for the number of species and total individuals in one quadrat respectively. Shannon-Wiener index: $H' = - \sum Pi \ln Pi$. Pi stands for the number ratio of number i specie in one quadrat. Pielou's evenness index: $E = H'/ \ln S$. Mann-Whitney U test was used to analysis the difference between different areas. Interannual change was analysed by Friedman test. The significant level was set at $P < 0.05$. Statistical analyses were conducted in SPSS 23.0 (SPSS Inc., USA).

3. Results

3.1. Changes of plant community structure under the disturbance of plateau pikas

Community height had an obvious decline trend from NA to AA (Table 1). In 2011, community height didn't have significant difference between NA and TA, but they are all higher than in AA ($P < 0.05$). Changing trend in 2012 was the same as 2011, and the difference became more significant ($P < 0.01$). Significant interannual difference was not found in all 3 areas.

While vegetation coverage had an obvious decline trend from NA to AA, the same as community height, interannual changes had different trends in different areas (Table 1). In both 2011 and 2012, vegetation coverage in NA was greater than in TA and AA ($P < 0.01$), and no significant difference was found between TA and AA. Significant interannual difference only existed in TA ($P < 0.05$).

3.2. Changes of functional groups under the disturbance of plateau pika

Plateau pikas had different impacts on the height of different functional groups (Table 2). Plants height had no significant difference between NA and TA in all 4 functional groups, and they all higher than that in AA ($P < 0.01$). Grasses was the highest in NA and TA ($P < 0.01$), sedges was shorter than the other 3 in TA ($P < 0.01$), and no significant difference was found between the other 3 functional groups

Table 1
The interannual changes of phytocoenosium parameters in different areas.

Year	Parameter	NA	TA	AA
2011	Height/cm	11.0 ± 1.5^a	10.7 ± 2.5^a	2.5 ± 1.6^b
	Coverage/%	86.2 ± 2.0^a	79.5 ± 3.7^b	74.5 ± 8.3^b
	Aboveground biomass/$(g \cdot m^{-2})$	250.7 ± 18.8^a	217.8 ± 16.2^a	178.1 ± 19.6^b
	Plant density/(m^{-2})	3445 ± 682^a	3139 ± 689^a	2737 ± 739^a
	Species number counts	41	40	30
	Shannon-Wiener index	2.38 ± 0.18^a	$2.26 \pm 0.17^{a,b}$	1.88 ± 0.31^b
	Pielou evenness index	0.64 ± 0.05^a	0.61 ± 0.05^a	0.55 ± 0.09^a
	Margalef richness index	3.82 ± 0.26^a	$3.37 \pm 0.31^{a,b}$	2.79 ± 0.42^b
2012	Height/cm	11.3 ± 1.5^a	8.7 ± 2.3^a	2.5 ± 1.5^b
	Coverage/%	87.9 ± 3.5^a	77.0 ± 4.8^b	74.8 ± 8.7^b
	Aboveground biomass/$(g \cdot m^{-2})$	252.5 ± 47.2^a	196.3 ± 19.2^b	202.3 ± 44.0^b
	Plant density/(m^{-2})	3400 ± 648^a	2743 ± 401^a	2943 ± 1011^a
	Species number counts	41	38	30
	Shannon-Wiener index	2.41 ± 0.19^a	2.17 ± 0.12^{ab}	1.84 ± 0.29^b
	Pielou evenness index	0.65 ± 0.05^a	0.60 ± 0.03^a	0.54 ± 0.09^a
	Margalef richness index	3.87 ± 0.21^a	$3.16 \pm 0.29^{a,b}$	2.69 ± 0.41^b

Note: Values are presented as Mean ± SD. Values with different letters are significantly different.