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The density of active burrows of plateau pika in relation to biomass allocation in the alpine meadow ecosystems of the Tibetan Plateau

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ABSTRACT

Understanding the relationships between plateau pika population and plants biomass is essential for improving small herbivores management in alpine meadow ecosystems. Four degrees of active burrow densities were classified to evaluate pika populations and biomass allocation interactions. Our results showed that plant composition, overall vegetation height and cover, dominant species were significantly different among four sites. Additionally, plant functional groups, above ground, below ground and total biomass, root:shoot ratios and the living roots proportion were the greatest at the zero-density site, and those at the medium-density site were the lowest. We postulate that pika activities may not be the cause of the differences, but a symptom of grassland degradation. Further, pika population fluctuations should be monitored, and when the population exceeds the economic threshold of low-density (110 pikas or/and 512 active burrows ha^{-1}) or reaches high-density (200 pikas or/and 1360 active burrows ha^{-1}), integrated management strategies should be implemented to protect damage.

1. Introduction

Plateau pikas (*Ochotona curzoniae*) are small lagomorphs, endemic to parts of the Tibetan Plateau in the People's Republic of China, India and Nepal (Bagchi et al., 2006). In the past, plateau pikas have been traditionally viewed as competitors with domestic livestock for forage, as well as agents of pasture desertification, soil erosion and vegetation disturbances (Zhang et al., 2003). On the other hand, plateau pikas also play a key role in maintaining ecosystem functions as a keystone species for providing a food resource for large mammalian predators and avian predators (Zhang et al., 2003). Additionally, some abandoned tunnels provide homes for lizards, ground squirrel and native birds (Delibes-Mateos et al., 2011). An alternative view of plateau pikas is that they contribute to the overall health of alpine meadows by aerating the soil *via* their burrowing

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activities, promoting nutrient recycling within alpine ecosystems, plateau pikas have also been shown to impact soil water retention and erosion (Li and Zhang, 2006).

Like other small herbivores, such as plateau zokors (*Eospalax fontanierii*), European rabbits (*Oryctolagus cuniculus*), pocket gophers (*Thomomys bottae*), prairie dogs (*Cynomys ludovicianus*) and water voles (*Arvicola terrestris*) in other grasslands types around the world, plateau pikas appear to have both detrimental and beneficial, direct and indirect, and long-term and short-term impacts on grassland ecosystems (Davidson et al., 2012). When the pika populations reach a high density, eradication campaigns have been performed by local governments and organizations for many years (Zhang et al., 2003).

The impact of pika on grassland ecosystem is dominated to a great extent by species abundance. To our knowledge little data exists on the impact of pika activities with population densities on community dynamics, plant functional groups (PFGs), roots or biomass allocation. We addressed the following three questions. (i) How can plateau pika population density be quantified? (ii) What are the impacts of pikas activities with different active burrow densities on biomass allocation? (iii) How should herbivorous small mammal population in the alpine meadow ecosystems be managed effectively?

2. Methods

2.1. Study region

The Tibetan Plateau is located in southwest China with a high altitude and harsh environment, and occupies 2.5 million km^2, approximately 25% of the country's area with an average elevation of > 4000 m. The climate shows strong seasonality, with a range of monthly mean temperature from −12.4 °C in January to 9.8 °C in July. The annual mean precipitation is 580 mm, 70% of which occurs in the summer between June and August. Principal soil types are Mat Cryic Cambisols and Mol Cryic Cambisols (Wang et al., 2008). The major plant communities are alpine meadow, alpine swamp, alpine shrub, alpine prairie and alpine steppe meadow (Zhou et al., 2005).

This study was carried out on the south-eastern flank of Qinghai Province in China, about 5 km west of the small town of Dawu, Maqin County, Guoluo Prefecture. Plateau pikas had not been eradicated in this area in recent five years, and all study sites consisted of gently undulating terrain within a similar habitat in Dawu valley with low, sparse alpine meadow grazed by yaks and sheep with heavy intensity in the cold season from September to the following May. Further, warm and cold season pastures rotational grazing were the basic and traditional grazing system for domestic livestock in Qinghai-Tibet plateau.

2.2. Experimental design

2.2.1. Plateau pika burrow density survey

Large circle sampling (2500 m^2) was used to investigate plateau pika burrow densities with the plugging tunnels method (PTM) in early May, 2008 (Sun et al., 2008). We randomly selected 12 sites equally spaced around herdsman residential area, with 0.5 km distance between sites where practically few subterranean zokor mounds were found and no zokors were trapped.

We assumed the grazing intensity of livestock and other native ungulates in this area was nearly the same. On the first day, the total observed tunnels (including fresh, abandoned and depleted burrows) were counted and to the burrows were then plugged with soil clod, hay, dry yak dung or anything that can be used to slightly cover the open burrows by hands or portable shovels. During the following three days, the opening burrows were counted and plugged repeatedly until the fourth day. The count of the first day was the total observed burrows, and the average count of next three days was the mean active burrows. In this study, we adopted the active burrow density to reflect the plateau pika population fluctuations (Sun et al., 2008). The burrow coefficient was summarized from the Grassland Station of the Maqin Bureau of Animal Husbandry.

Considering the major grassland types of alpine meadow, and the status of site habitat and active burrow cluster distribution, twelve survey sites were classified into four degrees (treatments) of pika active burrow density and each treatment had three replications: approximately zero-density (AZD), low-density (LD), medium-density (MD), and high-density (HD) sites, respectively (Table 1).

Table 1
Geographical, plateau pika abundance and burrows counts of sites AZD, LD, MD and HD (M ± SD). AZD-HD denotes four sites with different active burrow densities by plateau pikas. AZD, approximately zero-density; LD, low-density; MD, medium-density; HD, high-density.

Parameter	Site			
	AZD	LD	MD	HD
Total burrows (ha^{-1})	102 ± 24^a	1124 ± 86^b	2124 ± 172^c	2780 ± 233^d
Active burrows (ha^{-1})	48 ± 8^a	512 ± 54^b	864 ± 85^c	1360 ± 152^d
Pika abundance (ha^{-1})	0 ~ 15	15 ~ 110	110 ~ 200	200 ~ 300
Altitude (m)	3771	3769	3740	3751
Latitude	34° 27.862′	34° 27.647′	34° 28.030′	34° 28.197′
Longitude	100° 12.182′	100° 12.596′	100° 12.624′	100° 28.060′

*Values in the same row sharing the same letters are not significantly different from each other ($P \leq 0.05$).