ARTICLE IN PRESS

Rangeland Ecology & Management xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Rangeland Ecology & Management

journal homepage: http://www.elsevier.com/locate/rama

Grassland Community Composition Response to Grazing Intensity Under Different Grazing Regimes

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ARTICLE INFO

Article history:
Received 24 March 2017
Received in revised form 21 July 2017
Accepted 25 September 2017
Available online xxxx

Key Words:
continuous grazing
grazing intensity
grazing regime
plant community composition
seasonal grazing

ABSTRACT

Grazing plays a key role in many ecosystems worldwide and can affect the structure and composition of terrestrial plant communities. Nonetheless, how grazing management, especially grazing regime (yearlong continuous and seasonal grazing), affects the relationship between grazing and vegetation on alpine grasslands has not been extensively studied. Here, we performed a grazing experiment in Gangcha county of Qinghai province of the Qinghai-Tibetan Plateau to test the effects of different stocking rates and grazing regimes on grassland biomass and plant structure and composition. Six stocking rates (ranging from 0 to 5.62 sheep ha^{-1}) were used for continuous grazing, and three grazing intensities (1.72, 2.87, and 5.62 sheep ha^{-1}) were used for seasonal grazing (grazed only in the growing season, from June to October) at the study sites. Plant biomass and grass functional community composition were characterized in two different yr (2011 and 2012). Additionally, species richness and plant diversity indexes were estimated to quantify the impacts of grazing on plant community composition. Our results indicated that grazing intensity best explained the plant biomass decrease in low-productivity environments, and different grazing regimes also influenced these results. The shifts in plant community structure and composition in response to increased grazing intensity differed considerably between continuous grazing and seasonal grazing. Seasonal grazing maintained greater amounts of palatable plant species, and fewer undesirable species in plant communities when compared with the composition after continuous grazing. Our results emphasize the importance of grazing regime in regulating the effects of grazing on plant communities and the importance of seasonal grazing for ecosystem maintenance, especially in the Qinghai-Tibetan Plateau. This suggests that periodic resting of grasslands could be a good management strategy to keep palatable species, thereby minimizing undesirable species in the overall species composition.

Introduction

Domestic herbivore grazing is the primary land use of rangelands (grassland) worldwide (Herrero and Thornton 2013). In water-limited ecosystems, aboveground net primary production is the main determinant of forage consumption by large herbivores, which is associated with meat and dairy production (Derner et al. 2008a; Craine et al. 2013; Reeves et al. 2013) and hence economic return (Torell et al. 2010; Ritten et al. 2014). Such herbivores have strong effects on the composition, richness, physical structure, and successional patterns of plant communities across multiple biomes and continents (Bakker et al. 2006; Beguin et al. 2011), and changes in their abundances can lead to dramatic direct and indirect effects on plant-animal interactions and ecosystem processes (Young et al. 2013). However, the magnitude and direction of the effects of herbivores on plant communities are variable (Vesk and Mark 2001) and influenced by grazing management. Nonetheless, how grazing management, especially grazing regime (yearlong continuous and seasonal grazing), affects the relationship between grazing and vegetation on alpine grasslands has not been extensively studied.

Grazing intensity can elicit vegetation changes through shifts in dominant plant functional groups (Derner and Hart 2007; Derner et al. 2008b; Lauenroth and Burke 2008). The response of plant composition varies according to grazing intensity (Deng et al. 2014). Previous studies have indicated that increasing the grazing intensity in the shortgrass steppe and northern mixed-grass prairie results in changes of plant functional groups and composition (Derner and Hart 2007; Derner et al. 2008b). Changes in vegetation composition from palatable grasses and sedges to less palatable forbs resulting from heavy grazing have been reported in many ecosystems (Sun et al. 2011 in northwest China; Zatout 2014 in Libya; Bakker et al. 2003 and Koerner and Collins 2014 in North America and South Africa, and Cingolani et al. 2003 in Argentina). These studies have shown that proper grazing intensity may increase plant biodiversity and promote species equitability (evenness) by removing competitive dominant species (Schultz et al. 2011). Therefore, a better understanding of the effects of grazing

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https://doi.org/10.1016/j.rama.2017.09.007
1550-7424/

Please cite this article as: Zhang, C., et al., Grassland Community Composition Response to Grazing Intensity Under Different Grazing Regimes, Rangeland Ecology & Management (2017), https://doi.org/10.1016/j.rama.2017.09.007

intensity on the dynamics of plant composition in relation to sustainable utilization is required for rational management of grasslands. Moreover, grazing timing (or grazing regime) is another factor affecting the plant composition of grasslands. Sternberg et al. (2015) suggested that different grazing regimes had different effects on plant composition. Seasonal grazing gives grasslands a time window for plant restoration, which might increase their resistance to grazing and change the development of plant composition, especially under heavy grazing. Therefore, grazing regime (seasonal grazing) may be used as a management tool for the maintenance of high production and biodiversity in grasslands.

The Qinghai-Tibet Plateau is one of the world's most extensive and highest grazing ecosystems. More than half of the plateau is covered by the alpine grassland, which supports some 70 million livestock (Zhou et al. 2006). Recently, the grazing pressure on this plateau has been increasing due to human population expansion. Owing to its important ecological and environmental roles at both regional and global scales, this alpine ecosystem has attracted abundant attention. However, little information is available on how grazing regime affects this unique alpine ecosystem. In particular, comparative analyses of continuous and seasonal grazing regimes are needed.

In this study, we examined the roles of grazing regime in regulating the response of local plant communities to different grazing intensities in the Qinghai-Tibetan Plateau. Our specific objectives were as follows: 1) to analyze seasonal variation in total aboveground biomass and its response to grazing management, 2) to study the responses of plant functional groups to changes in the timing and intensity of grazing, and 3) to assess the relationships between the grazing intensity and species richness, species diversity index, and equitability under different grazing regimes.

Materials and Methods

Study Site

The study was conducted in Gangcha County in the northeastern part of Qinghai Province (37°21′N, 100°04′E, 3 313 m above sea level; for detailed site characteristics, see Wang et al. 2016), 200 km from Xining, the capital city of Qinghai Province (Fig. 1). The study site is flat, with a slightly undulating plateau. The site experiences a continental monsoon-type climate with an annual temperature ranging from −17.5°C (January) to 11.0°C (July) and a mean annual precipitation of about 370.5 mm with approximately 79−93% falling in the short and cool summer (May−September). The growing season is closely associated with the rainfall distribution. The patterns of mean monthly temperature were similar in 2011 and 2012, but the precipitation was slightly greater in 2011 than in 2012 (Fig. 2). The alpine steppe vegetation was dominated mainly by *Elymus nutans* (Poaceae), *Kobresia humilis* (Cyperaceae), and *Stipa purpurea* (Poaceae). Other species were *Astragalus polycladus* (Leguminosae), *Heteropappus altaicus* (Compositae), *Koeleria cristata* (Poaceae), *Potentilla bifurca* (Rosaceae), *Radix bupleuri* (Apiaceae), and so on. Fire, either natural or human induced for pasture management, is uncommon in this area. The soil is classified as Mat-Gryic Cambisol (Luo et al. 2009), and is relatively homogeneous. Basic soil properties were organic C 21.16 g kg^{-1}, pH 7.67, total N 5.74 g kg^{-1}, and total P 0.73 g kg^{-1} at soil depths of 0–10 cm (Xu et al. 2015).

Experimental Design

A grazing experiment was established in June 2010, and grazing lands were subjected to 2 yr of grazing. Grazing treatments comprised

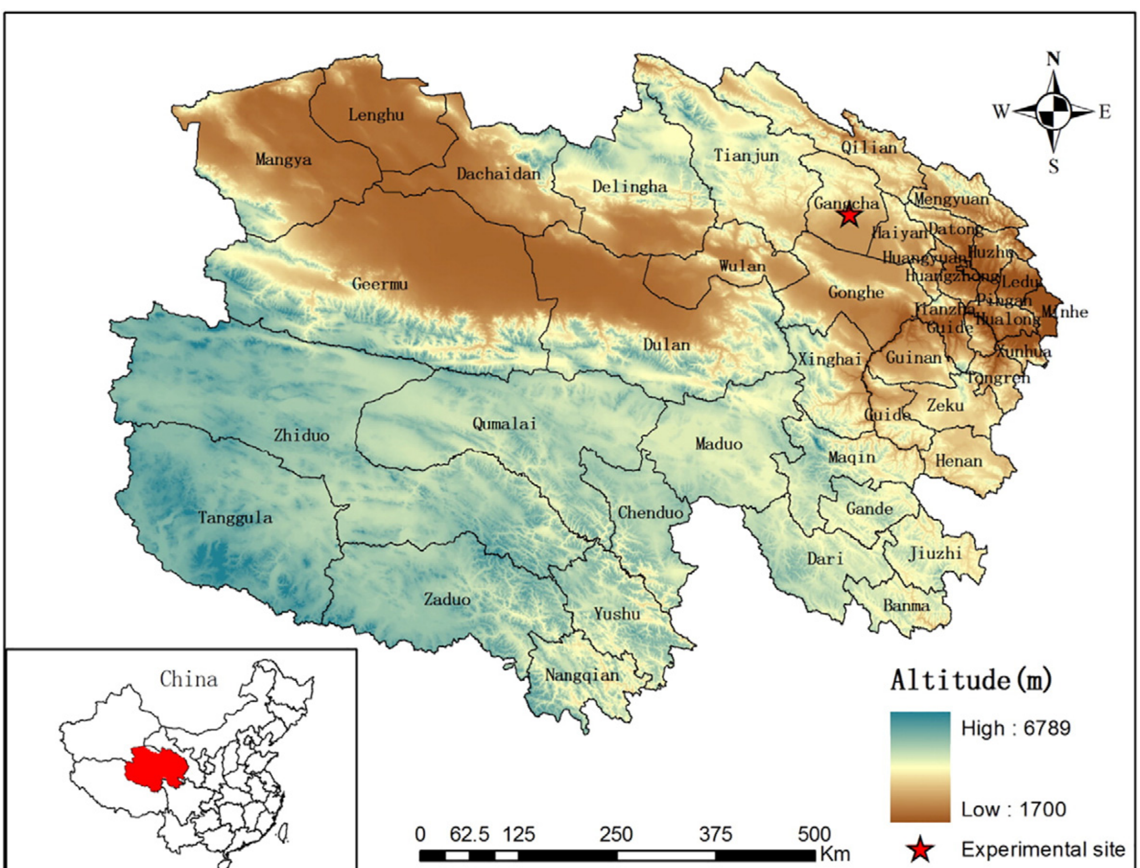

Figure 1. Location of experimental site.

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