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Plant and animal responses to different grazing regimes on a meadow steppe in Northeast China

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Introduction

Grazing by domestic herbivores is often considered to be an essential factor governing grassland vegetation and animal production (Hodgson and Illius 1996). During recent decades, there is increasing interest as a fundamental interaction between plant-animal interface, especially for the simultaneous or interactive responses of plants and animals to grassland grazing regimes (Liu *et al.*, 2015), which benefits on improving the efficiency of grazing or grassland resource management. To achieve sustainable animal productivity and maintain the stability of grasslands, farmers or stakeholders need to employ optimal grazing strategies or regimes based on practical grassland vegetation and environments. Unfortunately, up to date it remains unclear what grazing regime will favour animal production, and mitigate the grassland degradation resulted from long-term free grazing in the eastern areas of the Eurasian Steppe. For this study, we conducted a five-year grazing experiment to test how grazing intensity (mediate and heavy) interact with resting to impact on the performance of plants and animals in a meadow steppe, and estimate the effects of designed grazing regime in this region.

Materials and Methods

This study was conducted on a meadow steppe in southern region of the Songnen Plains, Northeast China (44°32'48" N, 123°39'58" E). There is a semi-arid continental climate with annual average air temperature ranging from 4.6-6.4°C, and annual precipitation of 280-400 mm. Soils are mixed saline and alkaline with pH ranging from 8.3 to 10.0. Vegetation is predominated by a formation of *Leymus chinensis* plus forbs, and other species are *Phragmites communis, Puccinellia tenuiflora, Apocynum lancifolium, Artemisia scoparia, Kalimeris integrifolia, Carex duriuscula, Taraxacum sinicum, Chloris virgata, Setaria viridis* and *Polygonum sibiricum*. The study site has been used to being a mowing pasture before 2009, and a fenced exclosure was established for grazing in 2008. Nine paddocks (each 1 ha) were set to grazing experiment. During May to September, sheep grazing (two grazing intensity levels: mediate grazing (MG), 4 sheep/ha; heavy grazing (HG), 6 sheep/ha) and no grazing were randomly assigned to these paddocks with three replications. Also, five resting treatments (SA1, SA2, SA3, SA4, SA5) in summer and autumn were nested to different grazing paddocks (Table 1). Sheep were grazing in the paddocks (from 06: 00 to 08 : 00 and from 16 : 00 to 18 : 00) to achieve the designed stocking rate during this period. Foraging behavior of individual sheep was carefully monitored, and intake mass was calculated as: I = IR (intake rate) × W (bite mass) × T (intake time). The monthly body weight or gain of sheep was recorded after grazing. Plant sampling with three transects was performed at pre- and post-grazing, and plant biomass, species richness and diversity index, and plant density were measured or estimated each month. Plant biomass (standing crops) was measured with dry matter (for 48 h at 70°C), and diversity index (Shannon-Weiner index) was calculated as following formula:

$H = -\sum (Pi)(\ln Pi)$ (*Pi* is the proportion of individuals represented by species *i* and *S* is the number of species).

Table 1: The layout of the treatments of grazing intensity and resting

Resting treatments	Grazing intensity (sheep/ha)	
	Summer (July-August)	Autumn (September)
SA1	6	6
SA2	6	4
SA3	6	0
SA4	4	6
SA5	4	4
Control	0	0

Results and Discussion

Plant traits and animal foraging with grazing intensities: It was shown that plant traits characterized as plant biomass and diversity varied with the treatments of grazing intensity, as well as the growing season (Fig. 1). Despite there were differences between 2011 and 2012 resulted from the different combination of air temperature and precipitation in the two growing seasons, plant biomass (standing crops) always reached a peak in August. In late summer and early autumn in 2012, this meadow steppe received much rainfall and then resulted in higher plant production. Unexpectedly, heavy grazing in 2011 significantly enhanced plant biomass (Fig. 1A), indicating that intensive grazing did not affect plant growth, which is similar with some artificial grasslands in America and European countries (high intensity with low frequency, HILF). The other finding is that the plant diversity (Shannon-Weiner index) was positively related to grassland resting (Fig. 1). In the growing season, there was higher plant diversity in resting plots than that in grazing plots. It could be attributed to the diet selection of grazing herbivores. In our study site, sheep appeared to selectively consume the forbs such as *A. scoparia, A. mongolica, and K. integrifllia*, but seldom foraged the dominant species *L. chinensis* (Zhong *et al.*, 2014; Liu *et al.*, 2015), which resulted in the declines of plant diversity, thereby potentially maintained the stability of grassland community. Finally, sheep intake in mediate and heavy grazing treatments increased from June to September, and compared to mediate grazing, heavy grazing significantly enhanced the sheep intake (Fig. 1). We did not test the underlying reasons from this experiment, however, it may be assumed that heavy grazing often promote plant biomass accumulation by inducing plant complementary growth.

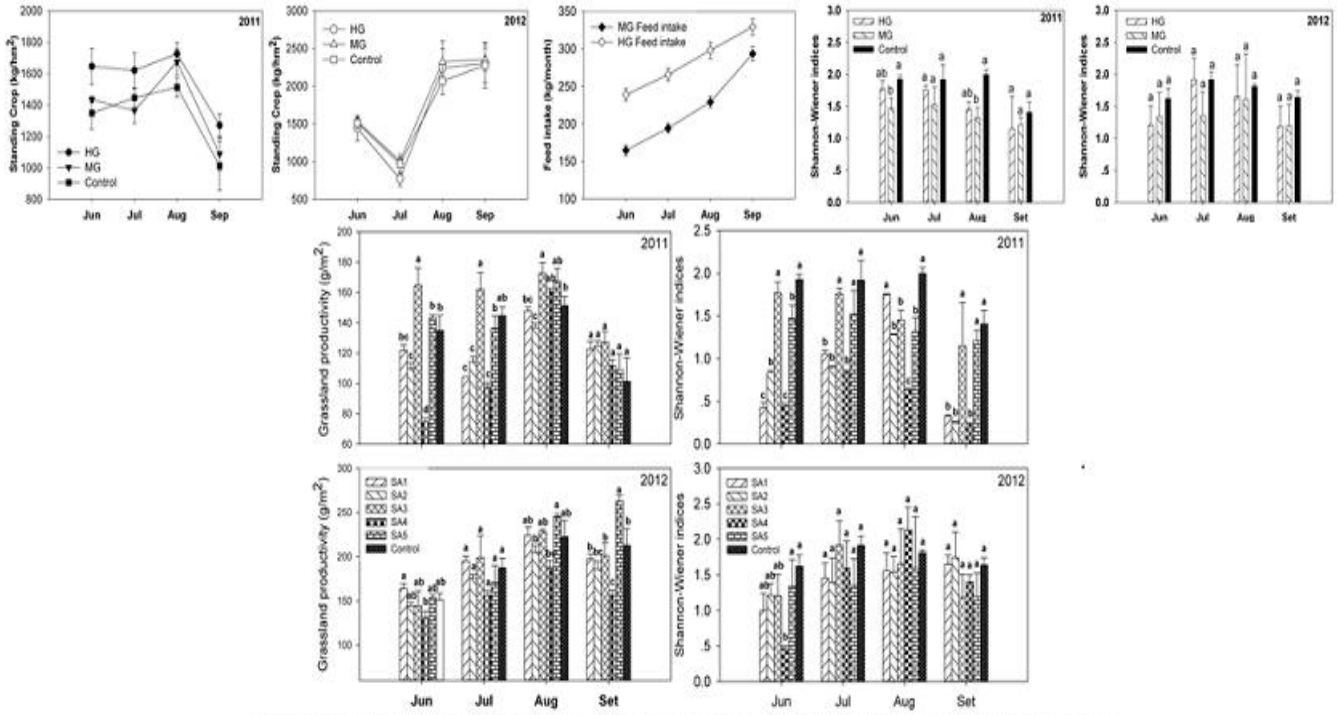

Fig. 1 Changes in plant biomass (standing crops), diversity index and animal intake with grazing intensities (2011-2012)

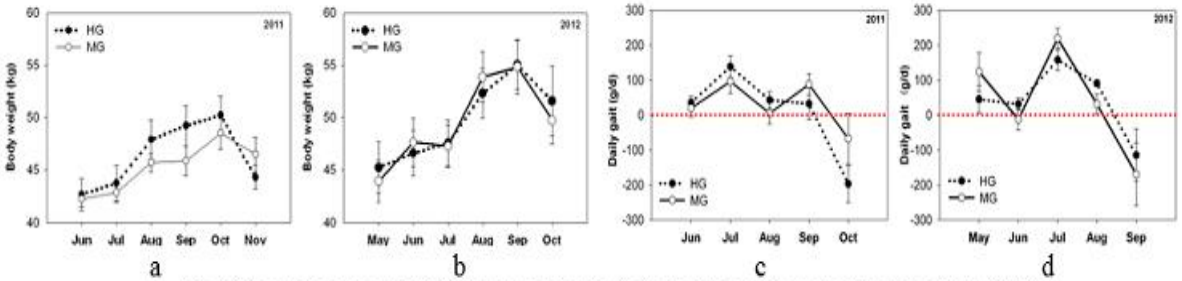

Fig. 2 Changes in body weight (a, b) and weight gain (c, d) of animals with grazing intensities (2011-2012)

Animal performance with grazing intensities: For this grazing experiment, it showed that there were seasonal changes in body weight (Fig. 2a, b) and weight gain (Fig. 2c, d) of animals with grazing intensities in 2011 and 2012. On the one hand, sheep body weight within mediate and heavy grazing treatments increased from June to September, and then had a reduction at the end of grazing season (September to October), which positively coincided with the changes in feed intake by sheep (Fig. 1). On the other hand, sheep weight gain (daily gain) showed the same increasing patterns with body weight, but the peaks of weight gain appeared in July (2011 and 2012), later than that of body weight, indicating that high plant production could partially contribute to animal performance or production, and the quality of plants fed by animals could play the important role in improving animal performance. At the end of the growing season, both of sheep body weight and weight gain simultaneously dropped sharply because of the reduction of plant quantity and quality. Interestingly, there were no statistical differences in sheep body weight and weight gain under mediate or heavy grazing (Fig. 2).

Conclusion

In conclusion, our study suggests that plants and animals characterized as traits and performance had responses to different grazing regimes. When it was considered to have two or more designed factors such as grazing intensity, and grazing or resting in the practical grazing systems, the responses of plants, animals or their interactions were complicated but changeable. From this experiment, we found the heavy grazing could maintain, even promote plant production. Although resting did not affect plant biomass, it benefited on the maintenance of plant diversity thereby the community stability. Finally, given that there was no difference in animal sheep body weight and weight gain for the two grazing treatments, the heavy grazing with more total animal production could be recommended under the favourable climate conditions in this area.

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