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The effects of grazing management strategies on the vegetation, diet quality, intake and performance of free grazing sheep

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ABSTRACT

The typical steppe is a major region for sheep meat production in north of china, but most of the area has now become degraded inducing serious constraints for livestock management. In this study we compared the effects of the grazing management strategies on herbage mass (HM), sheep intake, diet chemical composition, and digestibility, and on live weight gain (LWG) of sheep grazing in typical steppe of north china during the growing season. Five grazing management strategies which have different stocking rate at different season were evaluated. The grazing managements were no grazing in the late spring and stocking rate at 9.3 and 6.7 sheep/ha in the summer and autumn (SA1); no grazing in the late spring and stocking rate at 6.7 and 9.3 sheep/ha in the summer and autumn (SA2); continuous grazing at 9.3 sheep/ha through all seasons (SA3); continuous grazing at 9.3 sheep/ha through late spring and summer and changing to 6.7 sheep/ha in the autumn (SA4); continuous grazing at 6.7 sheep/ha through all seasons (SA5). The results showed that HM decreased from 1.0 t DM/ha at SA1 and SA2 to 0.34–0.37 t DM/ha in SA3 and SA4 ($P<0.05$). Diet crude protein (CP) and DOM were higher in SA3 and SA4 compared to those in SA1, SA2 and SA5 ($P<0.05$). However, neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) contents in the diet and OMI per kg LW/d showed the opposite trends. DOM was positively related with CP ($R=0.78$, $P<0.05$) and negatively with NDF ($R=-0.79$, $P<0.05$), ADF ($R=-0.69$, $P<0.05$), and ADL ($R=-0.67$, $P<0.05$). OMI was only correlated with HM ($R=0.39$, $P<0.05$) and ADL ($R=0.34$, $P<0.05$). Both LWG per sheep and LWG per ha were decreased with the order: SA1, SA2, SA5, SA3 and SA4, which was remarkably related with stocking rate at the different grazing periods. The observations showed pronounced effects of grazing intensity and grazing period on animal and grassland productivity. The results suggested that deferred spring grazing combined with higher stocking rates in summer and relatively low stocking rates in autumn would be the best grazing strategy in this steppe. The study confirms the current central government's policy of defer spring grazing is benefit for the grassland productivity and ecological service. Therefore, the studies provide valuable evidence that farmers' practice of high stocking rate and grazing throughout the growing season are not sustainable for the grassland utilization.

1. Introduction

Native grasslands in China cover 400 million hectares, about 40% of the land area (Wang and Ba, 2008). Forage produced on native grassland is the predominate source of livestock feed in semi-arid region of China. In the last decades, the native grassland was extensively degraded through over-grazing and over-exploitation of natural resources. Sustained utilization of these grasslands may improve the long-term animal performance as well as protect grassland from degradation and maintain ecological stability (Kemp and Michalk, 2007; Li et al., 1999). Many studies showed that recovery

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periods of the grassland after grazing are important for maintaining productivity of grasslands. This recovery period can be realized either by reducing the amount of animals during the grazing periods (Schönbach et al., 2009) or by preventing grazing in critical periods (Li et al., 2001, 2005; Zhao et al., 2003). Spring grazing can reduce herbage mass by reducing plant cover and vegetation height (Li et al., 2005; Yun et al., 2010; Zhao et al., 2003). This will in turn decrease the herbage intake and performance of livestock (Li et al., 2005). Even though grazing sheep display a higher selective intake behavior at different stocking rates due to differences in herbage quality offered and ingested (Han et al., 2000; Kristensen, 1988; Wang et al., 2011). Stocking rate and grazing period may also influence feed quality and affect the herbage intake and animal performance (Glindemann et al., 2009; Lin et al., 2012). An assessment of dietary nutrient content of forage and dry matter intake by sheep on such grazing resources is necessary to formulate suitable grassland management strategies and to identify variations in herbage mass and nutrient content that constrain animal production.

In this study, the effects of grazing strategies on herbage mass (HM), diet quality; organic matter intake (OMI) and live weight gain (LWG) of sheep were evaluated. The hypothesis in this study is whether the spring grazing is a critical factor and grazing intensity should be varied according to the growing season on the steppe. The objectives of the study were tested the effects of grazing season and grazing intensities on the variables of herbage mass and animal performance which included the following aspects: 1. The effects of two different summer and autumn grazing strategies; 2. The effect of no spring grazing with a high stocking rate in the spring; 3. The effect of the moderate and high stocking rates in the autumn; 4. The effects of the moderate and high stocking rate throughout the season. This study will provide valuable information for developing grazing strategies during the growing season and providing guides for adjusting grazing management strategies based on herbage mass availability and sheep performance.

2. Materials and methods

2.1. Study area description

The research was conducted on the national grassland ecosystem research station (long 115°46′E, lat 41°44′N, alt 1380 m, which is located in the semi-arid region (annual rainfall 300–400 mm of which 60% falls during the period of June to August) of Hebei province in China. Summer temperatures are warm with very cold winters, and the mean annual temperature is 1 °C. Mean temperature in January is −18.6 and 17.6 °C in July (Fig. 1). Annual evaporation is 1736 mm, which is more than four times of the annual rainfall. Mean annual relative humid is 63%. Mean length of the frost-free period is 85–95 days (Huang et al., 2007).

The natural dominant species are *Leymus chinensis* and *Stipa gradis*. Other species are *Arteminsia frigida*, *Cleistogenes squarrosa*, *Agropyron crsistatum*, *Iris lacteal* and *Potentilla acaulis*. The total cover of the vegetation is 60–70% and the average height is 25–30 cm. The mean annual aboveground biomass is 1540 kg DM/ha, and 900, 1590 and 1350 kg DM/ha in the spring, summer, autumn respectively. The topography of the study area is flat. The soil belongs to chestnut soil group (Chinese classification system) or calcic-orthic aridisol (US soil taxonomy classification system) characterized by fine and sandy structure with total nitrogen (410.7 mg/kg), available nitrogen (242.6 mg/kg), total phosphorus (64.7 mg/kg) and pH 8.8. Because our 15 study plots all derived from the steppe, so all of them share the same climatic conditions, soil type, parent material and topography, the potential differences can be attributed to different grazing management practices.

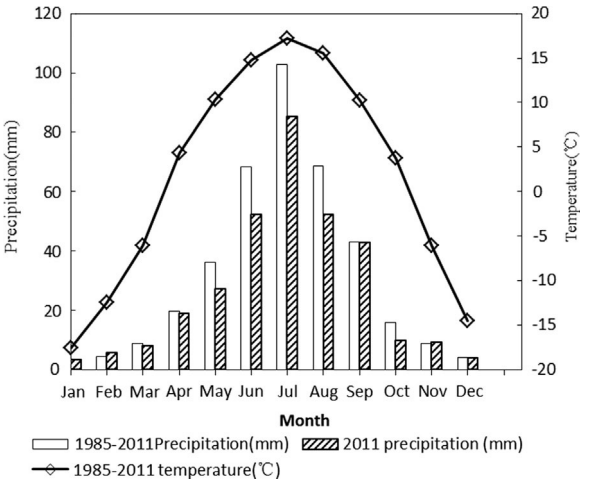

Fig. 1. Monthly mean air temperature and precipitation at the study site (1985–2011).

2.2. Design of the grazing experiment

The grazing trial started from the growing season of 2009, and the measurements were conducted during the growing season of 2011, which totalize 92 consecutive days. This period of time was divided into three phases (grazing periods), which were late spring (15 June to 12 July), summer (13 July to 15 August) and autumn (16 August to 15 September). We tested three different grazing intensity (0 sheep/ha, 6.7 sheep/ha and 9.3 sheep/ha) combined with grazing periods composed of nine grazing management strategies. However, in this grazing trial we only evaluated five different grazing management strategies with three replicates (Table 1). The total grazing area was 22.5 ha divided by three blocks with five plots in each block. The size of each plot was 1.5 ha. Non-pregnant and non-lactating female sheep of the local fat-tailed breed were used. Sheep were between 1.5 and 2 years old with an average live weight of 37.4 ± 3.6 kg. The number of grazing sheep was 114 in July, 186 in August, and 174 in September respectively. During the grazing period the sheep had free access to water and minerals in lick stones. Animals were treated against ectoparasites in July.

2.3. Herbage mass and diet chemical composition

Herbage mass (HM) was determined on 3–5 July, 4–6 August and 4–5 September during each fecal collection