Effects of grazing strategies and stocking rate on reproduction and abundance of three bunch grasses in typical steppe of Inner-Mongolia, China

H. Wan[1], P. Schönbach[1], M. Gierus[1], Y. Bai[2], F. Taube[1]

[1]Institut für Pflanzenbau und –züchtung, Grünland und Futterbau/ Ökologischer Landbau, Hermann-Rodewald-Strasse 9, 24118 Kiel; E-mail: Hwan@email.uni-kiel.de

[2]Laboratory of Quantitative Vegetation Ecology, Institute of Botany, the Chinese Academy of Sciences, Beijing 100093, China

Introduction

Typical steppe is widely distributed in Inner-Mongolia. Most of this natural resource is used as pastures for livestock, such as sheep, goat, cattle, horse, and camel. Whereas due to livestock population increasing and unreasonable utilization, large area of grassland is degraded, and accompanied by a series of severe ecological and environmental problems such as decreased grassland productivity, soil erosion and sandstorm. So, finding a better way of pasture management, sustainable using of these natural resources is a pressing issue, which need to be faced and solved. According to previous studies on grazing ecology (Teague & Dowhower, 2003), we hypothesize that grazing and hay-making mixed management system under reasonable stocking rate can help to solve this problem. In order to compare the differences of traditional and mixed management systems and define the optimum grazing range, a field grazing experiment was established in 2005, including two types of rangeland management ways (traditional and mixed), two utilization types (hay making and grazing), and 6 stocking rates (ranging from 1.5 to 9 sheep/ha, i.e. very light to very heavy grazing intensity). Here we present the results from the field investigation which was conducted in 2007. The major focus is on the effects of grazing strategies and stocking rate on reproductive tiller ratio and species frequency of the following three abundant bunch grasses: *Cleistogenes squarrosa*, *Agropyron cristatum* and *Stipa grandis*.

Materials and Methods

The grazing experiment is located in the Xilin-River Basin, Inner-Mongolia Autonomous Region, China (116°42′E, 43°38′N, 1100 m a.s.l.). In 2005, an area of about 120 ha was fenced and divided into 56 small paddocks to carry out our grazing experimental design. It includes two utilization ways (hay-making and grazing); two grazing management systems (traditional and mixed), traditional system means continuing grazing and hay-making at fixed paddocks, mixed system means we interchange hay-making and grazing of each paddock yearly; two block (flat and slope) and 7 grazing intensities (0, 1.5, 3.0, 4.5, 6.0, 7.5, 9.0 sheep/ha). Proportion of reproductive tillers (RT_t) of *S. grandis*, C.

squarrosa and *A. cristatum* were measured once in middle of August, at 4 grazing intensities (0, 1.5, 4.5, 7.5 sheep/ha, which we selected to stand for no, light, medium and heavy grazing treatment separately) of both management systems and both utilization ways. In each paddock, 30 randomly choosen bunches of each species were counted, we recorded the number of vegetative tillers and reproductive tillers for each bunch, for reproductive tillers we make records for both intact reproductive tillers and grazed reproductive tillers. RT_t is calculated on tiller basis, and it is equal to the sum of proportion of intact reproductive tillers (RT_i) and proportion of grazed reproductive tillers (RT_g, means the reproductive tillers which were partially grazed by sheep). Frequency of *S. grandis*, C*. squarrosa* and *A. cristatum* were investigated right after we finished the reproductive tillers' ratio measurement, in the same paddocks with point cycle method. 50 random points were choosen in each paddock, and in each point all species which present in the cycle with radius of 5 cm around the point were recorded. Frequency of each species was equal to total amount individuals of target species in 50 observed points divided by the total amount individuals of all species presented in 50 observed points. Mixed model was used to analyze the system and intensity effects, least square means were used to draw figures.

Results and discussion

Seed production plays an important role in recruitment of new generations, particularly for species which have limited vegetative reproduction ability. Therefore, disturbances which influence the seed production of these species will have strong effects on their population, and finally influence the whole community structure. *S. grandis*, C*. squarrosa* and *A. cristatum* are three widely distributed perennial bunch grasses in typical steppe, and seedling recruitment is the only way for their population expansion. Here we present the results of grazing and uitilization strategies effects on percentage of reproductive tillers of these 3 species, after three years running of field grazing trial. And, in order to test the correlations between species' seed production and their population sizes, we show the effects of grazing and management on frequencies of *S. grandis*, C*. squarrosa* and *A. cristatum* as well.

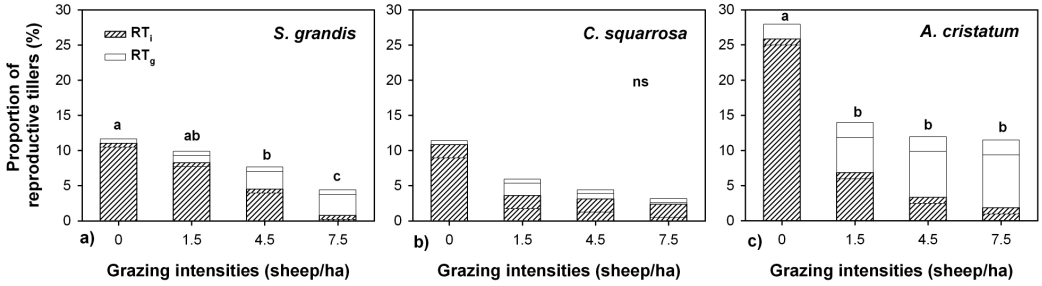

Fig. 1: Effects of stocking rate on proportion of reproductive tillers of *S. grandis* (a), C*. squarrosa* (b) and *A. cristatum* (c). Bars with different letters mean significant differences (P<0.05) of RT_t (sum of RT_i and RT_g), ns means not statistically significant.

Stocking rate had strong influence on proportion of reproductive tillers (RT_t) of *S. grandis*, C*. squarrosa* and *A. cristatum* (Fig.1). Compared to ungraze plot (0

sheep/ha), RT_t of heavy grazing decreased by 67%, 92% and 69% for *S. grandis*, C*. squarrosa* and *A. cristatum* respectively. We also found that the percentage of intact reproductive tillers (RT_i), which seeds could achieve maturity, was much less compared to ungrazed plot, because a large part of reproductive tillers were selectively grazed by sheep, particularly for *A. cristatum* (Fig.1).

Management system effects were not so strong (Fig. 2). We observed that in traditional system, RT_t of *S. grandis* and C*. squarrosa* tended to be higher, and RT_t of *A. cristatum* tended to be lower (Fig. 2). The RT_t were consistently higher in hay-making plots, ranging from 2% to 10% for all three investigated species in both management systems. This data suggests that in mixed system, during the hay-making year the plots have chance to get more seed production.

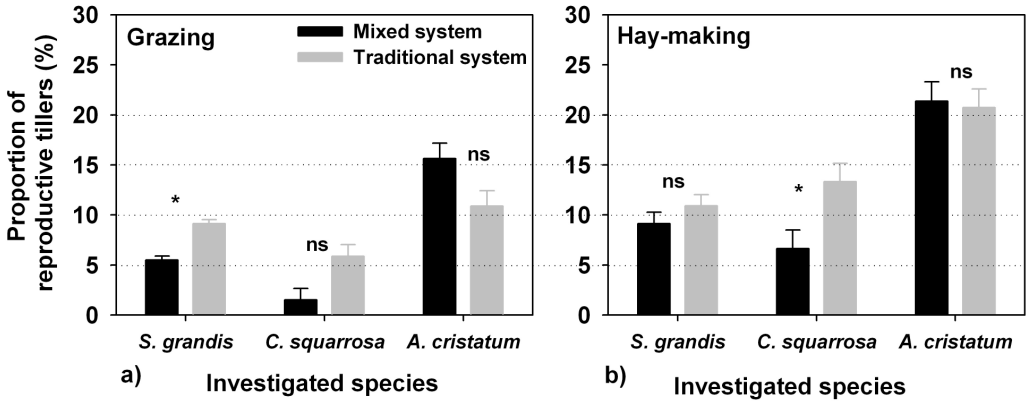

Fig. 2: Effects of grazing management system and utilization way on RT_t of *S. grandis*, C*. squarrosa* and *A. cristatum*. ns means not siginicant of the paired bars, * means significant difference between the paired bars (P<0.05).

Stocking rate had no strong effects on frequency of three observed species, and it was relative stable after 3 years of experiment establishment (Fig. 3). The frequency was about 15%, 20% and 7% (In grazing system), and 17%, 23% and 8% (In hay-making system) for *S. grandis*, C*. squarrosa* and *A. cristatum* respectively.

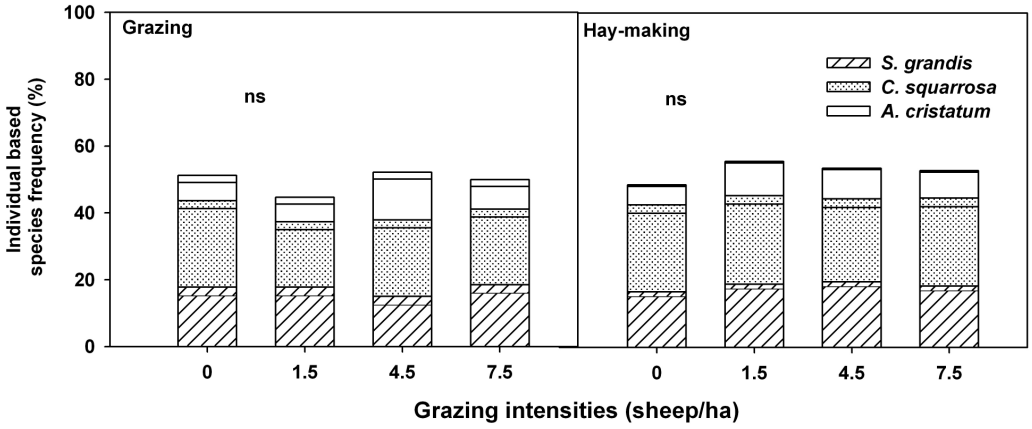

Fig. 3: Effects of stocking rate on individual based species frequency of *S. grandis*, C*. squarrosa* and *A. cristatum*.

Mixed system had higher frequency of C*. squarrosa* and *A. cristatum*, and lower frequency of *S. grandis*, particularly in hay-making plots (Fig. 4). These differences might attribute to pre-experimentary effects, since the areas of the two management systems were managed by two farmers. We also could see that frequency of *S. grandis*, C*. squarrosa* and *A. cristatum* was slightly higher (1% to 3%) in hay-making plots compared to grazing paddocks (Fig. 4).

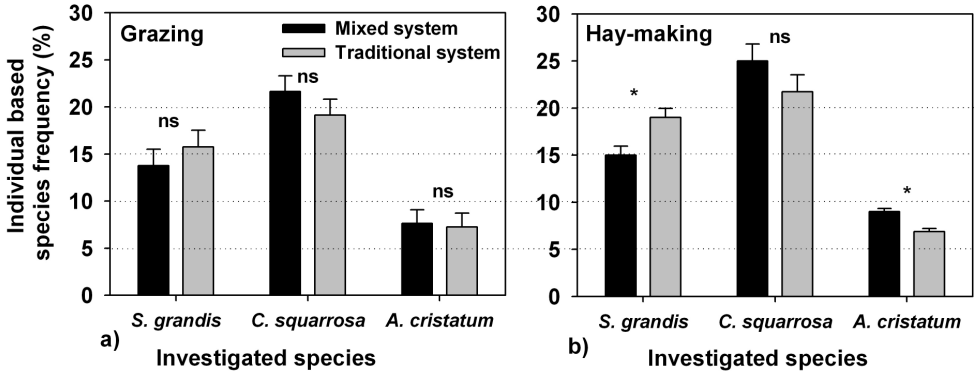

Fig. 4: Effects of management system and utilization way on frequency of *S. grandis*, C*. squarrosa* and *A. cristatum*.

Combining the two parts of results we found that frequency of *S. grandis*, C*. squarrosa* and *A. cristatum* didn't show the same trends along the grazing intensities as proportion of reproductive tillers (Fig. 1 and Fig. 3). The population of these 3 perennial bunch grasses was relative stable, and it reflected that the community is resistant to short term stocking rate changes. Species frequency and RT_t under different management systems didn't show the same trends as well (Fig. 2 and Fig. 4). Whereas frequency and RT_t of the 3 investigated species showed the same trends under different utilization ways (Grazing and Hay-making). Although frequency of those species increased only about 1-3% in hay-making plots (Fig. 2 and Fig. 4), we think that long term running of the experiment will make changes in species frequency more clear.

Conclusions

After 3 years running of field grazing experiment, we found that stocking rate and utilization ways have strong effects on reproductive tillers, and these changes may have strong influence on soil seed bank, and finally impact population size of there species and the community structure. Stocking rate had no strong effects on species frequency as what we have observed for species reproductive tillers in the short term. It reflects that the population has ability to resist short term grazing disturbance. A long term running of the grazing experiment is necessary for detecting grazing effects on plant population and community structure, which will help us to understand the mechanics of steppe degradation processes.

Literature

TEAGUE, W.R. & DOWHOWER, S.L. (2003): Patch dynamics under rotational and continuous grazing management in large, heterogeneous paddocks. *Journal of Arid Environments* 53, 211-229.