Journal of Animal and Veterinary Advances 13 (16): 963-969, 2014
ISSN: 1680-5593

Responses Strategy to Morphology of Fringed Sagebrush (*Artemisia frigid*) to Grazing Intensity in Desert Steppe of Inner Mongolia

[1, 2]Guomei Yin, [2]Yongzhi Liu, [1]Yingjun Zhang, [3]Jinhua Zhao,
[4]Junying He, [2]Yanlin Xue and [5]Xiaoqing Zhang
[1]Department of Grassland Science, College of Animal Science and Technology,
China Agricultural University, 100193 Beijing, P.R. China
[2]Inner Mongolia Academy of Agricultural and Animal Husbandry Science,
Inner Mongolia, 010031 Hohhot, P.R. China
[3]Inner Mongolia Agricultural University, Inner Mongolia, 010018 Hohhot, P.R. China
[4]Inner Mongolia Normal University, Inner Mongolia, 010022 Hohhot, P.R. China
[5]Chinese Academy Agricultural Sciences,
Institute of Grassland Research, 010010 Hohhot, P.R. China

Abstract: To investigated the tolerance response of Fringed sagebrush (*Artemisia frigid* Willd.) to three grazing intensities in the desert steppe of Inner Mongolian in China, the relationships between them were analyzed from two different aspects, plant height and leaf epidermis micro-morphology. As grazing pressure increased, plant height was the better trait of grazing response. At the height level researchers predicted that plants with a negative response to grazing would be ingest by sheep with grazing intensity increasers. At the leaf epidermis micromorphology level, researchers predicted that with higher grazing intensities would have stomatal subsidence, skin folds increase. The results of this exploratory study suggest that prediction of grazing responses on the basis of easily measured plant traits is feasible and consistent between similar grazing systems in different regions. The results challenge the precept that high intensity sheep grazing necessarily change species with micromorphology and height.

Key words: Response, Fringed sagebrush, grazing intensity, height, leaf epidermis micromorphology

INTRODUCTION

Experiments on vegetation responses to grazing management in different grasslands have studied the effects of grazing on grassland (Gibson *et al*., 1987; Gibson and Brown, 1992; Smith *et al*., 1996, 2000; Grant *et al*., 1996a, b; Bullock *et al*., 1994). Grazing on plant communities induce responses and changes in the community. The species varied with the level of stress (water and nutrient availability) and disturbance (grazing and ploughing) on different condition. Plant character affected or induced by herbivores are very diverse (Agrawal, 1999, 2000; Gomez and Zamora, 2002; Young *et al*., 2003; Bi *et al*., 1997; Takabayashi and Dicke, 1996) in different regions. The explanation and prediction of plant community responses to grazing intensity is therefore a major objective in applied as well as theoretical ecology. Plant species of grasslands are used to express characterize for their exist strategy according to by morphological (size and shape) and functional (growth, reproduction and phenology). Disturbance is related to shape and phonology relations between plant attributes and habitat characteristics are examined within the more general framework of plant strategy theory. Plant height is a trait recognized as important in the plant response to grazing (Westoby, 1999; Diaz *et al*., 2001). Decreases in plant height in response to grazing by ungulates have been repeatedly documented in the study (McNaughton, 1984; Noy-Meir *et al*., 1989). While some results suggest that a short stature could be a mechanism of grazing avoidance (Sala *et al*., 1986) others have documented the preference of herbivores for short lawns in relation to tall grasslands (Hunter, 1962; Bakker and Ruyter, 1981). Therefore, there is a growing need to understand and predict plant responses to different land management factors in terms of plant traits that are easily measured and at the same time ecologically meaningful (Hodgson *et al*., 1991).

In present study, researchers study the character of height and leaf epidermis micromorphology in Fringed

Corresponding Author: Yingjun Zhang, Department of Grassland Science, College of Animal Science and Technology, China Agricultural University, 100193 Beijing, P.R. China

sagebrush for classification in the future and recognize its ecological habits. The goal of its trait studies is to predict the grazing intensity of plant communities by combining knowledge of the nature and strength of different environmental drivers and the response of its traits to the drivers. Within this context researchers analyzed Fringed sagebrush sets from desert grasslands of Midwest in Inner Mongolian in order to answer the following questions: Do plants with contrasting responses to grazing differ in terms of easily measured traits such as plant height, micro-morphological? What is the trait of those measured that can better explain and predict the response of species in different grazing intensity?

MATERIALS AND METHODS

Site description: The study was carried out on the Siziwang Banner (41°47'17"N, 111°53'46"E) located in the middle of Inner Mongolia, approximately 150 km (Li and Li, 2002) North of Hohhot, the provincial capital. It is in the Northern piedmont of Yinshan Mountain on the Mongolia Plateau, covers an area of 25,500 km^2 and has a human population of 209,000 many of them dependent upon agricultural activities for their livelihoods. Altitude averages 1,450 m. Mean annual rainfall is 250 mm most variable in June to July for the year. The climate is windy in Spring and mostly dry throughout Autumn, Winter and Spring. The Summer is short and hot, Winter period is long and cold. The annual average temperature in the region varies from -15°C in January to 20°C in the July. Shallow snow often covers the ground for between 50-130 days. The soil is mainly composed of steppe soil which is commonly calcified. The vegetation is that of the Inner Mongolia desert steppe which the main species being: *Stipa braviflora*, *Stipa gobica*, *Stipa klimenzii*, *Cleistogenes songorica*, *Cleistogenes squarrosa*, *Allium mongoliaum*, *Allium polyrhizum*, *Allium tenuissmum*, *Convolvulus ammannii*, *Hetropappus altaicus*, *Lagochilus ilicifolius*, *Artemisia scoparia*, *Artemisia pectinata*, *Ceratoids lantens*, *Artemisia frigida*, *Kochia prostrate*. At present, vegetation can be sparse (17-20% cover) with a very limited species composition and richness.

Experimental design: The stocking rate trial was initiated in 2004 as a completely randomized block design with four grazing treatments and three replicates. The different grazing treatments in the trial would be listed above studied effects up to 10 years. The 12 plots (4.4 ha) in total were fenced and stocked with sheep at rates of 0, 0.15, 0.30 and 0.45 sheep/ha/month. These rates were defined as Control (CK), Light Grazing (LG), Moderate Grazing (MG) and Heavy Grazing (HG), respectively. From 2004 to 2012, grazing plots were grazed from June 1 to November 30 for each year. Grazing sheep were not randomly reassigned each year but were retained in their originally assigned plots during the experimental period. The sheep were usually kept in the experiment for 3 years and then replaced by 2 years old animals from the same flock. If the sheep died that would be replaced by others that were of a similar liveweight and age during this period. The sheep were given access to the plots from 06:00-18:00 every day and then penned over-night. To supply with water and salt for the animals twice every day (at early morning and evening) in their pen. In Winter, the sheep were maintained in confinement on a diet of hay, wheat chaff and some grains until the end of May.

Plant height analysis: The plant of Fringed sagebrush prepared for this study was collected from the Siziwang Banner Experimental Site in 2012, test base of Institute of Inner Mongolia Academy of Agricultural and Animal Husbandry Science. To measure the height for the Fringed sagebrush species were taken from a sample of each paddock at vegetative in July. All samples in mean area per squaremeter (1×1 m^2). Plant height was expressed with centimeter (cm). Plant height was measured from the base to the tip of the highest at least 10 individuals. The parameters were determined for each individual and then averaged perspectives. The statistical analyses were carried out in order to answer different grazing response groups.

Structure of leaf epidermis: The adult leaves approximately at the same age were taken from fully expanded sun-exposed and cut into small blocks along the vein with 0.5 cm^2. The material for Scanning Electron Microscopy (SEM) observation was macerated in FAA solution about 48 h, dehydrated in a series of gradient alcohol. Subsequently, the plant material was mounted on stubs with double-sided adhesive tape and sputter coated with gold-palladium. Artier gold sputtering, the specimens were examined and photographed at 30 kV under a quanta 300, 400 and 800 scanning electron microscope at room temperature. The classification proposed by was followed in determining the type of stomata and the terminology was adopted for other characters.

RESULTS AND DISCUSSION

Plant height: Groups of Fringed sagebrush associated with different levels of stocking rate were identified graphically using a partial of the effects of grazing intensity. Researchers were able to identify height of the specie that was significantly associated with each of grazing intensity. Vegetation was significantly affected by grazing intensity. Moderate and heavy intensity of grazing was associated with shorter plants while light grazing intensity was associated with taller plants relatively. No grazing was associated with the tallest plants. The significant was the difference in the representation of heavy and light in the grazing response groups (Fig. 1).

Epidermal cells: Under SEM observation, the upper epidermis cells of Fringed sagebrush are polygonal and irregular in form with anticlinal walls straight to arched, sinuous or shallow undulate and periclinal walls depressed. The patterns of anticlinal wall on the low epidermis cells Fringed sagebrush is deep undulate or sinuous, while the periclinal wall is depression and its surface is either smooth with shallow depressions or

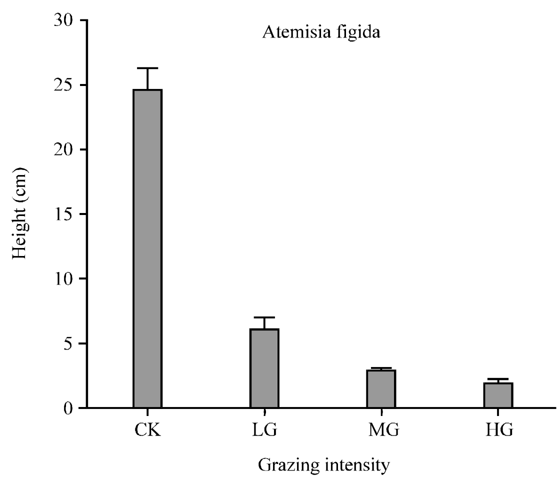

Fig. 1: Height of Fringed sagebrush in different grazing intensity condition

sculpturing (Fig. 2 and 3). From studying micromorphology on the upper epidermis of the Fringed sagebrush, it can be seen that the anticlinal walls wax nodular in MG and HG treatments were significantly higher than that in CK and LG treatments (Fig. 2 and 3). Leaf cuticular ornamentation of epidermal cells is relatively more under the moderate and heavy grazing condition, the leaf epidermis of grain is relatively smooth and less under no and light grazing condition.

Stomatal apparatus: The stomatal apparatus of Fringed sagebrush were distributed in upper and lower epidermis. It is for irregular shape, guard cells flanks and thicken protrusion, stomatal outside the arch cover nearly smooth grain, smooth around the inner arch (Fig. 3 and 4). From studying the stomatal of the Fringed sagebrush, it can be seen that the stomatal apparatus is obvious difference under different grazing intensity. The stomatal apparatus is relatively small and sunk in horny layer under the condition of heavy and moderate grazing. The stomatal apparatus is located in the horny layer and bulge out the position under light and no grazing conditions. In addition, the hair on the lower leaf epidermal of Fringed sagebrush is more dense (Fig. 5) in heavy grazing area. Because an airproof environment is formed to decrease water loss from stomata transpiration.

Range management is based on the response of plant species and communities to grazing intensity. The identification of easily measured plant certain traits (height and morphology) that consistently predict grazing response in a wide spectrum of rangelands would be a major advance. This study has shown that traits have been shown to predict grazing responses to explain grazing responses in semi-arid and arid desert grasslands of China. There were significant effects of plant height or leaf epidermis character on grazing responses. In China,

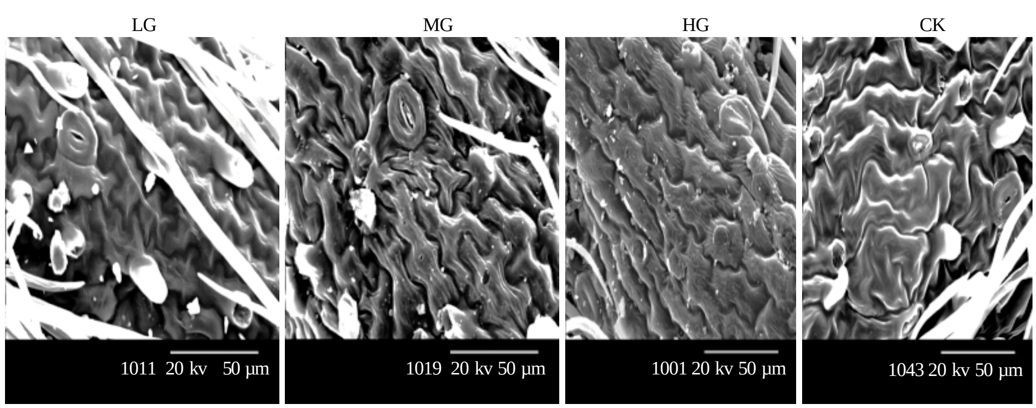

Fig. 2: Lower epidermis cells of Fringed sagebrush in different intensity grazing region. LG, M, HG and CK is defined as light grazing, moderate grazing, heavy grazing and no grazing, respectively

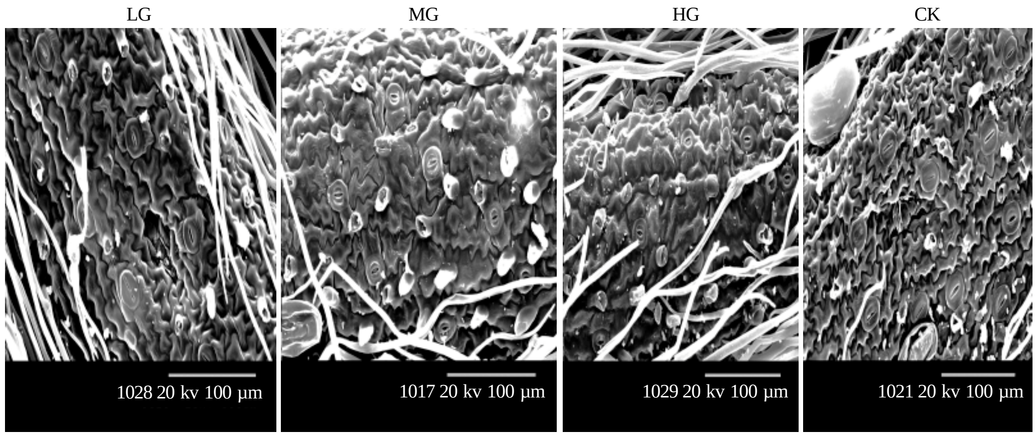

Fig. 3: Stomata of Fringed sagebrush in different grazing intensity condition. LG, M, HG and CK is defined as light grazing, moderate grazing, heavy grazing and no grazing, respectively

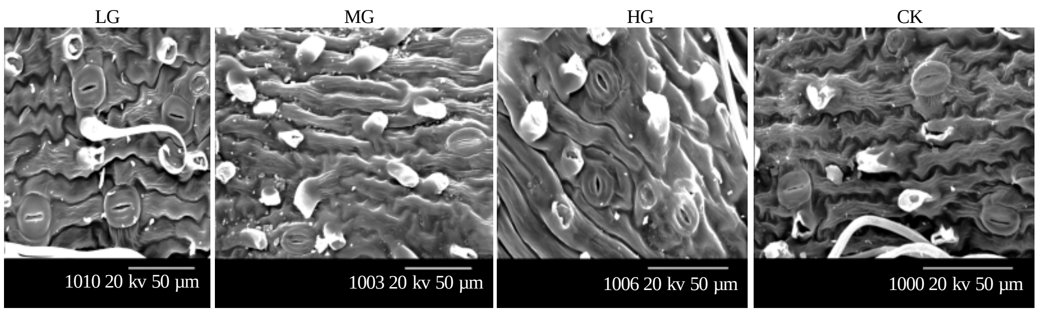

Fig. 4: Upper epidermis of Fringed sagebrush in different intensity grazing condition. LG, M, HG and CK is defined as light grazing, moderate grazing, heavy grazing and no grazing, respectively

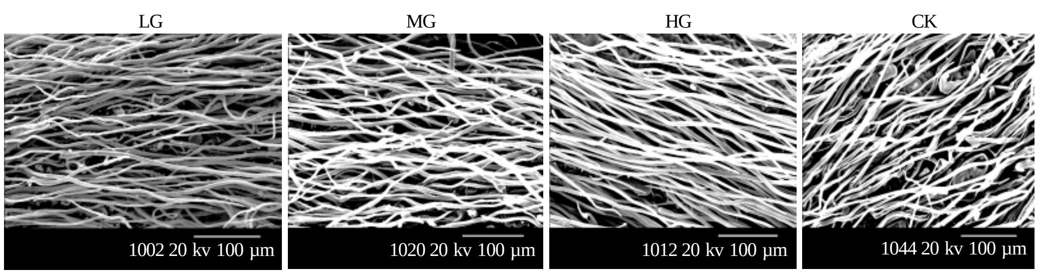

Fig. 5: Epidermal hair of Fringed sagebrush in different grazing intensity condition.LG, M, HG and CK is defined as light grazing, moderate grazing, heavy grazing and no grazing, respectively

desert steppe ecosystem is fragile and is difficult to restore. Grazing utilization is the main way of using in the region. Different levels of grazing utilization have different impact on the plant community. Grazing by domestic herbivores has both extensive and profound impacts on plant communities. The identification of plant traits that explain and predict the response of communities to grazing intensity is one of the main tools in management of grazing systems (Zhao and Wang, 2009; Wang *et al*., 1999; Smith *et al*., 1996). Almost a century of empirical research in rangelands in different parts of the world has been dedicated to identifying the response of individual plant species to varying grazing intensities. The results from many studies in North American grasslands have led to the formulation of generalizations on the plant types or plant traits associated with a negative or a positive response to grazing intensity grazing decreases or grazing increasers and invaders, respectively. Generalizations across communities and continents on plant traits that can explain or predict, responses of plant species to grazing intensity can be derived by theoretical considerations (Westoby, 1999) and evaluated by comparing or integrating information from communities in different regions.

Plastic responses of plants to contrasting environments have been frequently reported as adaptive (Sultan, 2000; Yang *et al*., 2005a, b). Differences among species and populations in their plasticity may reflect differential selective pressures on plasticity, differential limitations acting upon the maximization of plasticity or a combination of both. The mean height of grazed tillers and its variance were greater under moderate than under heavy stocking. The grazers eat from top down and so most importantly, tall species receive most grazing pressure and short species benefit by avoiding leaf loss and through relaxed competition. In this trait, the height of grazing response is decrease with the grazing intensity increase.

Leaf as the biggest apparatus is exposed to the environment and leaf epidermal characteristics are of optimal taxonomical importance. It appears that stomatal and other epidermal features are constant within species and thus maybe used in analysis and discussion. The leaf morphology is affected in the extreme by the environment. Thereby, studying the leaf morphology can realize its ecological adaptation on leaf-structure such as well-developed epidermal hair, conducting tissue and mechanical tissue. For example, some plants adopt the protective ecotype to drought environment and have the well-developed epidermal hair and the wax like, water repellent cut in covering the epidermis which can reduce transpiration and radiation (Yang *et al*., 2005a, b; Wang *et al*., 1999). Moreover, the plants also can decrease water loss when the stomata turn off timely. Some plants also take the abstemious ecotype to fit aridity for example, Fringed sagebrush. The resistant strategies is adopted which have well-developed conducting tissue and mechanical tissue to supply, enough water for live. As an adaptive consequence, plants in the drought area developed various drought-resistant tolerance mechanisms to adopt the drought stress environment which are determined by environmental and genetic factors.

The study on changes of the genetic diversity and model of Fringed sagebrush were conducted (Wang *et al*., 2004, 2006; Wang and Ma, 1999). In this study, the results showed that Fringed sagebrush have the leaf epidermal micromorphology characteristics, i.e., stomata, trichomes. Under SEM observations, Fringed sagebrush in heavy intensity has sunk stomata. Because the environment in the heavy grazing paddock is relative drought. Drought resistant species should have high density stomata which maximize the rate of carbon gain while minimizing water loss (Shields *et al*., 1950). The stomata apparatus are ruleless and are distributed on the lower and upper epidermal is in Fringed sagebrush. Meanwhile on the lower epidermis, bushy trichomes including glandular hair and non-glandular hair are observed. Well-developed epidermal hair and depressed patricidal walls can minimize transpiration (Fahn, 1986). So, researchers could infer that Fringed sagebrush adopt the water save ecotypes to high grazing intensity and drought environment. Moreover, it can be concluded that Fringed sagebrush in heavy grazing intensity has the stronger drought-resistance and uses water more efficiently than light grazing intensity from the leaf epidermal feature because Fringed sagebrush has more epidermal hair on the epidermal which forms a relatively airproof space and reduces water loss from stomata under severe water deficit and is efficient water use types (Fahn, 1964).

The long-term study is important because responses to management such as grazing may evolve over many years. This study shows the need for long-term experimental analyses of community responses to grazing as vegetation responses may develop for a long time. The traits analysis suggests it is possible to predict changes in species composition under grazing through an understanding of the mechanisms of plant responses. Grassland managers require such information in order to manipulate grazing regimes to achieve. This strategy of coping with grazing is distinct from grazing avoidance, one of the most commonly reported strategies in range management literature (Dyksterhuis, 1949).

CONCLUSION

Population of Fringed sagebrush was able to identify height of the specie that was significantly associated with each grazing intensity. High intensity of grazing was associated with shorter plants, viceversa. Under SEM observation, the anticlinal walls wax nodular raised in moderate and heavy grazing condition is more significantly than light grazing. Leaf cuticular ornamentation of epidermal cells is relatively more under the condition of heavy and moderate grazing than others. The stomatal apparatus under the condition of heavy grazing is relatively small and sunk in horny layer.

ACKNOWLEDGEMENTS

This study was supported by Inner Mongolia Natural Science Fund Project (No. 2011BS0404) Young Fund Project of Institute of Inner Mongolia Academy of Agricultural and Animal Husbandry Science

(No. 2014QNJJM04, 2013QNJJM10) Grants-in Project Special Fund for Agro-scientific Research in the Public Interest (No. 201303059, 201003061) and National Forage Industry System. Researchers would like to acknowledge the researchers on whose research this study is based. Thanks to all drafts on Siziwang experiment base of Institute of Inner Mongolia Academy of Agricultural and Animal Husbandry Science.

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