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Research Progress of Grassland Feed-animal Balance at Home and Abroad

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Abstract Feed-animal balance is the key technique on the grassland ecosystem management, and attracts widespread attention in the world. Many studies have been conducted by former researchers, and most of their efforts were intended to keep the balance of feed-animal. However, there are still much more issue needed to be studied in details on the face of grassland degeneration and animal husbandry sustainable development. The author analyzed the feed-animal balance research progress, including the concept of stocking rate and its practical management techniques, especially on the stocking rate calculation methods. In addition, the social and economy effects on feed-animal balance were also discussed during the progress of improving the development of pastoral economy. In order to achieve feed-animal balance more effectively, it was concluded that the focus must be shift from only on animal number to the grassland quality, and it's necessary to strengthen market tax control.

Key words Feed-animal balance, Grazing capacity, Herbage yield, Feed intake

1 Introduction

There is 400 million hm² of grassland in China, which is about 40% of the national territory. At present, 90% natural grassland degrades at different degree and this increases at a speed of 2 million hm² each year. Apart from natural reasons, human influence is another major reason for the degradation of grasslands. Moreover, the increasing number of farmers and the rising industrial demand push forward the sustaining rise of animals number, which restricts the development of husbandry industry. According to the calculation of remote sensing center in Agricultural Department, grassland in North China has passed 36.1%^[1]. The degrading grassland is because of inappropriate resources allocation, extensive management, low production level, poor economic benefit, and slowly increasing income, which would intensify the contradiction between reducing productivity and increasing animal number. Government at all levels have implemented many measures to protect and recover the ecology of grassland, such as "restricting husbandry, stopping husbandry, reconverting farmland into forest". So far, the tendency of regional treatment and all-round deterioration of grassland has not been effectively contained^[2].

To keep animals and grass balance means to provide forage to animals through grassland or other ways^[3]. This is not simply a question of grass. In fact, it is a matter of "people – livestock – grass", or to be more specific, it is a matter of "people – grass". To keep grass and livestock balance is the premise of sustainable

utilization of natural grassland and efficient production of animals. Li Xiaomin *et al.*^[5] studied the difference of vegetation constituents, and proposed to manage grass amount by controlling the amount of animals, which not only can preserve healthy growth of grass, but also contribute to the development of animal husbandry on the grasslands.

Studies by Jones *et al.*^[6] suggested that with the same carrying capacity, the amount of grass when the animals are grazing unrestrained has always been lower than the amount when animals are grazing in rotation. Studies by Ralph^[7] *et al.* indicate that grazing in rotation in a short time would increase the output of grass and improve the utilization and animal carrying capacity at per unit. Chinese scholars proposed many concrete measures on grazing based on the current grazing situation in China and advanced management experience in foreign countries: grazing in spring, feeding in winter, rotation grazing and seasonal grazing. Li Qinfeng, Yao Aixing, Zhao Gang^[8–11] *et al.* proposed the idea of not-grazing in spring by comparing unrestrained grazing and restrained grazing, and thought not – grazing in spring can effectively protect the ecological environment of grassland. Wang Qiji *et al.*^[12–16] studied the production structure of family grazing and livestock feeding and proposed optimal management production mode, which showed essential social economic and ecological benefits. Duo Jielong *et al.*^[15] used linear planning to build mathematic model and took many measures to improve the conservation of grass. Studies by Han Guodong *et al.*^[17] proved that with regard to continuous grazing, rotational grazing is more beneficial to the improvement and growth of plants on the grassland.

At present, the management model to keep plants and animals balance is to give priority to strengthening administration and adjusting animals amount, which is against the rules on keeping the amount of grass and livestock balance, according to the rules in each province, autonomous region, city people's congress or its

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standing committee. However, along with social and technological development, the ways to use grassland have underwent drastic changes^[18]. Therefore, it is imperative for us to realize that the critical object should be changing management mode instead of focusing on the number of animals.

2 Balance of forage and livestock on the key technological level

Jia Youling^[4] pointed out that the forage and livestock balance means to keep reasonable carrying rate on the grassland. However, in reality, problems about keeping forage and livestock balance are more complicated. One of the most important one is the certainty of the carrying rate. However, in reality, carrying rate is the maximum stocking rate possible while maintaining or improving vegetation or related resources^[19–20]. It is often expressed as animal unit months. Li Bo *et al.*^[21], Yang Zhengli *et al.*^[22], Zhou Yongmei *et al.*^[23–24], Qian Shuan *et al.*^[25], Li Jianlong *et al.*^[26] have built related linear models of forage amount and grassland production potential in different places so as to study the forage-animal balance and carrying rate. Liu Xingyuan *et al.*^[27] used SPSS software and corresponding measured maximum NDVI and EVI value on the tenth day in each station to establish remote sensing monitoring model of NDVI, EVI and biomass on the grassland. Wang Mingjiu *et al.*^[28] estimated and made related studies on the carrying rate of grasslands in Inner Mongoulia in accordance to the nutrition supply of forage and nutrition demand of animals.

At present, studies on forage-livestock balance on crucial technological level focus on four aspects, namely forage output, animal demand for forage, forage use rate and carrying rate.

2.1 Total available forage Total available forage means the annual output of forage on the grassland, which changes according to the grassland type, measuring time and years. We must measure the total available forage on different kinds of grassland and different locations so as to get the mean value^[29]. At present, measures to evaluate the output of forage on the grassland can be divided as field measuring method, meteorological simulation model and remote sensing model.

Dong Kuanhu *et al.*^[30] conducted field measuring method at subalpine meadow to study the changes of forage output. Liang Wanpeng^[31] applied calculus theory based on abundant field investigation to calculate the teaching method of forage amount based on abundant field investigations. Li Yunpeng^[32] used satellite remote sensing data and concluded that it is feasible to measure the forage output on natural grassland based on MERIS – NDVI. Lieth *et al.*^[33] proposed Mialni model in 1971, a kind of net preliminary production model which regard mean annual temperature and mean annual precipitation as variables. Later on Donkor *et al.*^[15] established computerized PASTURE model and simulated the produce of forage and animal production capacity on northern grasslands in Alberta Province in Canada.

2.2 Animal demand of forage The demands of forage by livestock are key bases to determine the amount of fodder and nitro-

gen during grazing period. Meanwhile, it reflects the productive force of grassland and management level^[36]. There are many ways to determine the demands of forage in abroad. So far, most experts in abroad would use alkane in the wax on plant epidermis to measure the demands of forage. The advantage of alkane is that it can not only be used as inner source indicator, but also be regarded as out source indicator^[37–38]. There are also many ways to determine the animals demand of forage in China. The following are some examples.

2.2.1 Weighing method. Animals are feed for one time in the morning and afternoon respectively. Four aspects need to be measured before weighing the animal: dung, hourly collection of urine, weighing, fixed quantity of feeding and fixed quantity of urine. The disadvantage of this method is that the amount of collected dung, and urine are quite large.

Animals' demand of forage = (Weight after eating + Dung + Urine) – (Weight after eating and drinking water) (1)

2.2.2 Calculation method. Through observing the break time for poultry, the time of eating, the type of plants being consumed, the eaten part, and the rest height, researchers simulate the type of plants, part and rest height of same kind of poultry. This method is time – consuming.

2.2.3 Feeding method. Feeding method can be expressed in the following formula,

$$W_n = (X_n - Y_n) / N \quad (2)$$

where W_n the daily collection of tested sheep(kg); Y_n the supply of mixed forage(kg); X_n the rest of mixed forage(kg); N the amount of raised sheep. This method is easy and relatively accurate.

2.2.4 Mask method^[40–42]. In this method, six fluffy sheep are separated into three groups for pasturing during the mid of each month. The weight of each sheep is recorded before pasturing. Two sheep with close age and weight are chosen, one for control and the other for the test. The test sheep would be wearing mask so it can breath and drink water but can not eat. After pasturing, test sheep are weighted so as to calculate the daily intake of poultry.

2.3 Forage use rate Forage use rate refers to the ratio of preserved forage for poultry in the total output of forage on the grassland^[43]. Huang Fuxiang *et al.*^[44] suggested that the use rate of forage on the arid and semi-arid grassland should take the effective covering rate of vegetation as standard. Anyuan *et al.*^[45] consider the dietary rate of maximum compensation duration. Lin Huilong^[46] thought it is far not enough to use the supply and demand relation of forage and livestock to manage the pasturing system. Scientific pasturing system also needs consideration of biomass and soil erosion. Even though for a long time, grassland carrying capacity plays extremely important role in keeping forage and livestock balance. However, there is no specific conclusion about appropriate carrying capacity yet^[47].

2.4 Carrying capacity At this moment, one of the most widely applied methods is forage output and daily feed of poultry. Its

concrete step is first to measure the mean output of available forage and to calculate carrying capacity based on feeding standard.

Carrying capacity =

$$\frac{\text{Pasturing output of grassland} \times \text{Effective use rate of forage}}{\text{Daily intake of poultry} \times \text{Pasturing duration}}$$

When it comes to using available forage amount to calculate carrying capacity, it is wrong to simply calculate the mean annual pasturing output^[48]. This method can unite grassland with livestock to a deeper level and reflect the relation between livestock demand and grassland supply. As this method does not consider the basics of grassland, it is seldom used in America. One Japanese scholar pointed out to use the nutrition supply of grassland and nutrition demand of poultry to calculate carrying capacity.

Keeping forage and livestock balance is the only way to solve current forage and livestock imbalance, and the fundamental way to realize the healthy and sustainable development of husbandry industry. However, because the output of grass on the grassland changes annually along with the climate variations, the heavy precipitation makes the grassland production unpredictable. Since shepherds need certain amount of livestock to sustain their life, it becomes barely impossible to measure the output of forage through existing measures^[49]. Those factors influence the execution of keeping forage and livestock balance.

The existing grassland treatment measures mostly focus on reducing livestock, and the influences of climate uncertainty and spatial and temporal scale are neglected. Li Yanbo *et al.*^[50] proposed not to keep forage and livestock balance by controlling livestock amount. Studies prove that it is inappropriate to apply fixed or conservative carrying capacity in the system of intense climate change. Yang Li *et al.*^[18] proved that keeping forage and livestock balance changed the surveillance model into a new market and economic management model based on grassland quality and tax collection. Right now, in America, traditional pasturing management has been replaced by ecological system management. The management model based on carrying capacity has been gradually replaced. The modern grassland management not only give full consideration to the sustainability of ecology, but also pay attention to the conservation and support of economy, society, entertainment, culture, heritage value and diversity. As the country which boasts the largest grassland in the world, Australia has applied cross-discipline method in making policies about keeping livestock and forage balance. In response to local grassland degradation, it is necessary to set up natural reserves to let the devastated grassland recover naturally.

Compared with other countries, pastoral areas in China abounds in grass, and the grassland management model is similar to that in America and Australia, but the management level is close to that in Asian African Countries, such as Syria and Algeria, etc. Considering those realities, there is still great room for grassland economy to development in China. Therefore, it is imperative to explore a kind of pasturing policy and management model that is suitable to Chinese national situation.

3 Conclusions and discussions

As the core of keeping forage and livestock balance, carrying capacity directly affects the entire grassland ecological system. Theoretically, carrying capacity is determined by the output and use rate of forage, as well as livestock, and is affected by climate, grassland condition and pasturing management, etc. However, keeping livestock and forage balance is a complicated system, involving every aspect of ecology, scientific technology, economy and society, etc. Pasturing system is a dynamic process^[51]. It is necessary to consider the dynamic changes of livestock, plants and grassland under certain economic background. Although there are many factors making it difficult to keep forage and livestock balanced, the finale result depends on shepherds. In order to increase income, shepherds would expand their livestock amount regardless of the ecology on the grassland. The compulsory policy from the government on reducing livestock amount meets shepherds resistance. Under such circumstance, Hou Xiangyang^[52] proposed to reduce livestock gradually. However, the exact measure has not been made yet, and it awaits further study. From now on, when it comes to management of resources on grasslands, it is necessary to focus on both ecological and economic outcome, to recognize grassland type systematically, to forget only pursuing livestock amount, to adjust carrying capacity appropriately, and to make innovative researches on the peculiarity and characteristics of grassland.

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