275

Sustainable management to reduce grasslands grazing pressure and improve household income in northern China

Rong, Y

College of Grassland Science and Technology, China Agricultural University, Beijing China 100193

Key words: Farm optimized model; household production; lambing time; pen feeding; seasonal grazing.

Abstract

Analyses of the status of current livestock production and alternative management practices for livestock production can help farmers improve their farming systems based on their particular local resources and markets. The farm surveys and parameterization of the models were developed by scientists and farmers working together to evaluate the effects of finances, grassland management, animal management and changes in farm infrastructure. Our study aimed to utilize bioeconomic models to optimize farm and livestock production systems in the agro-pastoral area in northern China. These analyses will hopefully lead to improved incomes, provide workable options for farmers and policy makers to restore grasslands and result in sustainable utilization of China's grassland resources.

To examine possible ways to sustainably manage grassland in the agro-pastoral areas, a formal survey of sheep farmers was conducted, and data from experimental trials were obtained in Hebei Province of northern China. The model of farm management analyzed annual feed supply and demand and showed that the gap of the annual feed supply and demand could be reduced by using improved sheep breeds for meat production instead of current breeds. The model of economy analysis showed that maximal profits could be achieved by using a combination of seasonal grazing at a grazing intensity of 5.4–6 sheep ha^{-1} and pen feeding. In addition, changing lambing time to November would reduce grazing pressure during the summer, which will be beneficial for grassland restoration and enhanced ecosystem services.

By obtaining accurate on-farm information from pastoralists and using these data to parameterize two models, realistic changes in management strategies were identified to increase farm income and reduce grassland grazing pressure. This activity increased public awareness of optimized farm management tools and provided a sound basis for identifying management alternatives for the sustainable management of grassland resources.

Introduction

Traditional livestock management practices in northern China are often based on survival through the year rather than producing goods for a market and running the farm as a business. What happens on these grasslands has important implications for millions of people in this region of China, and also safeguards the northern and the southeast cropland region of China. Analyses of the status of current livestock production and alternative management practices for livestock production can help farmers improve their farming systems based on their

particular local resources and markets (Takahashi et al. 2011; Komarek et al. 2012; Zheng et al. 2013). Model analysis of farm production provides a valuable tool for both government officials and farmers to optimize natural resource use for livestock production. Model solutions have been used to try and guide farmers to increase market access and develop quality standards, thereby making livestock production more profitable Parsons et al. 2011; Komarek et al. 2012; Zheng et al. 2013). The objective of our study was to utilize bioeconomic models to optimize farm and livestock production systems in the agro-pastoral area of Fengning County, Hebei Province in northern China. The farming analysis model was developed by scientists and farmers working together in the northern grassland area of China to evaluate the effects of finance, grassland and animal management and farm infrastructural changes (Kemp et al. 2011). The objective of our study was to utilize bioeconomic models to optimize farm and livestock production systems in the agro-pastoral area of Fengning County, Hebei Province in northern China. These analyses will hopefully lead to improved incomes, provide workable options for farmers and policy makers to restore grasslands and result in sustainable utilization of China's grassland resources.

Methods

Data to parameterize the models were obtained from various sources, including farm surveys, published information, expert opinions and field trials (Ma et al. 2014). Several functional relationships between various biological parameters and either grassland condition or livestock condition were derived using experimental trials in the local area (Figure 1).

Data collected from the farm surveys and field trials were used to parameterize two models: StageONE Feed-Balance Analyser Model and StageTWO Optimising Model (Takahashi et al. 2011). The model uses metabolisable energy to link feed supply, demand and utilization. Both models derive net farm livestock financial returns for the starting conditions using biophysical and financial data.

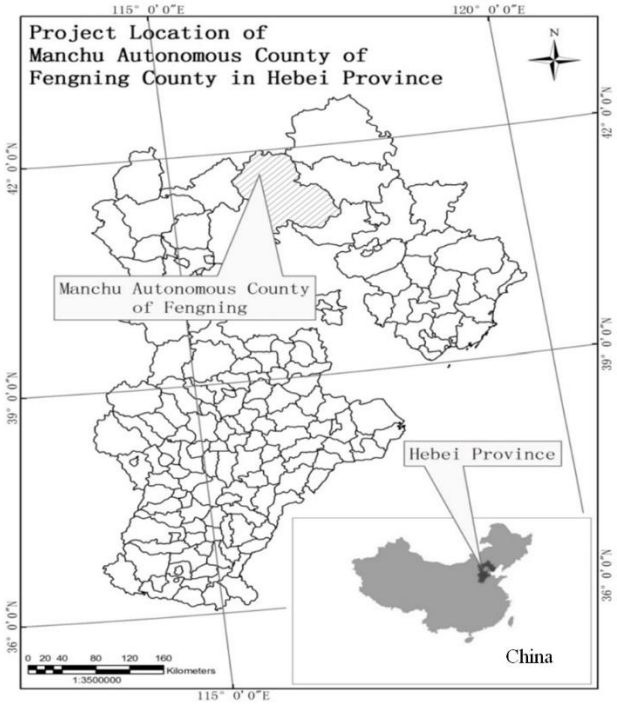

Figure 1 Study location of Fengning County, Hebei Province in northern China.

Results

Current sheep production system in Fengning County

In the southeast portion of the Mongolian Plateau, Hebei fine-wool sheep and small-tail sheep crossed with Mongolian sheep are the dominant livestock. The typical farm averages 5 to 8 ha of land for fodder (typically maize silage, oats, wheat and potatoes), and about 700 ha of grassland is communally used by the village. Lambs are born from January to March and sold at about 8 to 12 months of age, according to the herder's need and market price. Grassland is continuously grazed at a stocking rate of 4.0 sheep ha−1 throughout the year, resulting in very high grazing pressures. Though a few small household farmers feed sheep during winter, energy and nutrient deficiency are typical from late-September to May because of poor forage nutrition and animal management (Figure 2a).

Options for farm improvement using different sheep breeds

In recent years, most farmers switched their focus to meat production due to the favorable mutton market. Farmers prefer small-tail sheep to other varieties because of the high birth rate, though this variety is not good for meat production. Given the poor nutrition of animals during winter and the high cost of purchased fodder, one alternative strategy is to use sheep varieties with good meat production. Some local farmers have crossed local ewes such as small-tail sheep with German Merino rams or Dubo rams for improved meat production. These crosses can increase live-weight gain with grazing during the summer and pen feeding in winter. Data from these new sheep breeds and the pen feeding trial were used to re-run the StageONE Model. The model results showed that the energy gap between maintenance and actual feed intake was narrowed (Figure 2b).

Options for farm improvement by changing lambing time

Results from the StageONE Model showed that lambing in January through March resulted in a sub-maintenance level of energy intake for ewes during most of the year (Figure 3a). Lambing in Jan. would be predicted to result in a major feed deficit from January through April (60% of maintenance). April lambing was closer to the maintenance level during November to February, but resulted in a large feed deficit during March to June (50% of maintenance). Lambing in June enabled an improved feed equivalent during winter and spring; however, intake did not meet maintenance levels during summer grazing in June and July. Lambing in November allowed intake to reach maintenance levels for nearly the entire year. This strategy might be further improved by possibly selling lambs and cull animals earlier (3 to 4 months of age) and by providing good nutrition in feeding pens. By lambing in November, pregnant ewes would have a greater probability of accessing higher quality forage during the summer, resulting in a higher lamb birth weight.

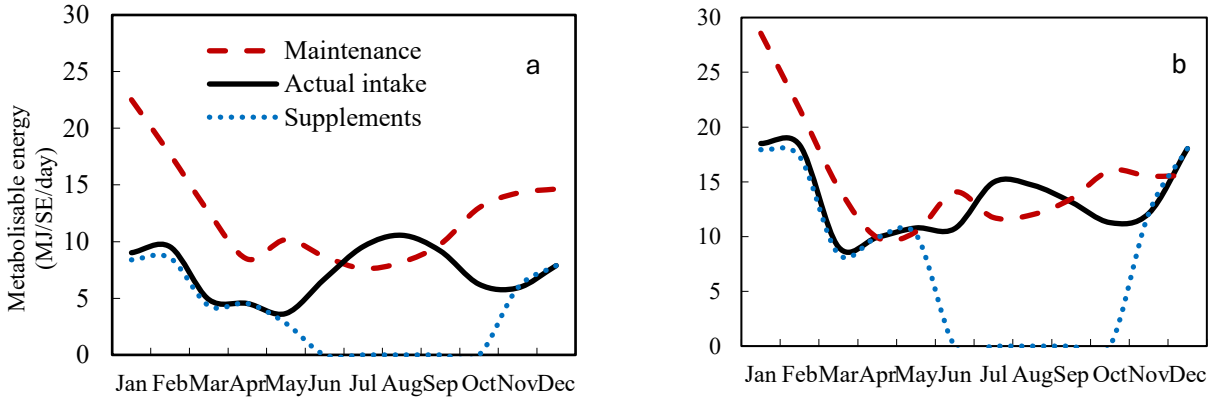

Figure 2 Metabolisable energy (ME) requirement, total ME intake and ME from supplements at the same live-weight per sheep equivalent for a typical farm in Fengning County, Hebei Province: a) current farm production and b) farm production using an improved sheep breed. (Note: Total ME intake is the intake of forage plus supplements. Ewes lambing in January).

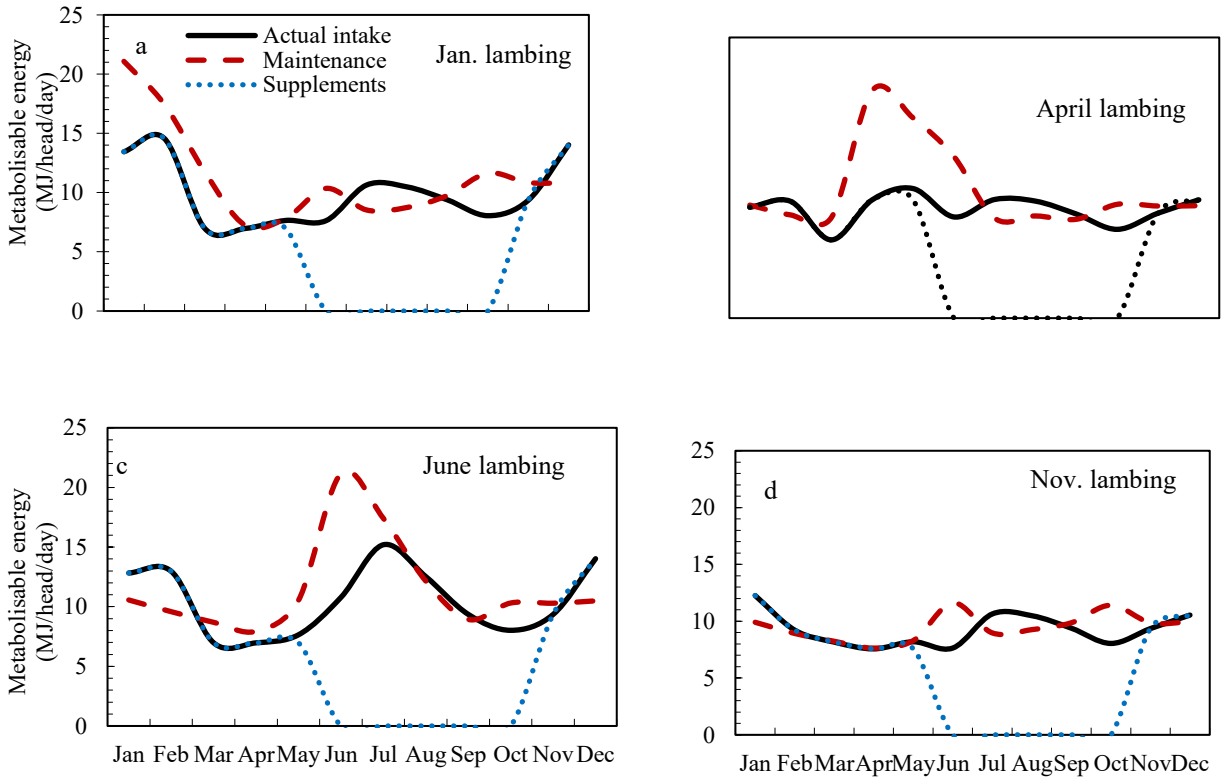

Figure 3 The effect of lambing time on feed energy balance for ewes in Fengning County, Hebei Province for: a) lambing in January (typical practice), b) lambing in April, c) lambing in June and d) lambing in November. With pen feeding from 15 Oct. to 15 June, feeding oat hay at 0.2 kg/day/head, alfalfa hay at 0.5 kg/day/head, maize grain at 0.1 kg/day/head, and other protein sources at 0.1 kg/day/head (ME = metabolisable energy).

Discussion

A key issue for managing livestock is maintaining a balance between livestock feed requirement and livestock feed availability (Darnhofer et al. 2010; Ma et al. 2014). Efforts to achieve this balance typically focus on increasing the forage and feed available to livestock and improved livestock performance through breeding (Herrero et al. 2009). Based on our local farm survey and the application of *StageONE* and *StageTWO* Models, we identified several strategies that may be beneficial for improving sheep management in northern China.

Analyses of the current livestock production status and alternative production management strategies through on-farm surveys and the application of model analysis showed the following changes should be made to the current farming system: 1) grasslands should only be grazed during the growing season, 2) pen feeding should be done during the non-growing season and 3) lambing time should be changed. These changes would better match local resources and lamb markets. The farm surveys and parameterization of the models were developed by scientists and farmers working together to evaluate the effects of finances, grassland management, animal management and changes in farm infrastructure. By obtaining accurate on-farm information from pastoralists and using these data to parameterize two models, realistic changes in management strategies were identified to increase farm income and reduce grassland grazing pressure. This activity increased public awareness of optimized farm management tools and provided a sound basis for identifying management alternatives for the sustainable management of grassland resources. Hopefully this process can be applied in other regions of China to more sustainably manage China's vital grassland ecosystems and improve the livelihood of pastoralists.

Acknowledgements

This work was financially supported by the National Key R&D Program of China (2021YFD1300503). Approval for animal experiments was obtained from China Agricultural University Laboratory Animal Welfare and Animal Experimental Ethical Committee (Approval No. Aw02402202-5-3).

References

Darnhofer I, Fairweather J, Moller H (2010) Assessing a farm's sustainability: insights from resilience thinking. *International Journal of Agricultural Sustainability* 8, 186–198.

Kemp D, Han G, Michalk D, Nan Zh, Wu J, Xu Z (2011) China's grassland livestock farming system: strategies and tactics for improvement. In: *Development of Sustainable Livestock Systems on Grasslands in North-Western China, ACIAR Proceedings No. 134* (Eds Kemp DR, Michalk DL), pp. 177–189.

Komarek AM, McDonald CK, Bell LW *et al.* (2012) Whole-farm effects of livestock intensification in smallholder systems in Gansu, China. *Agricultural Systems* 109, 16–24.

Ma L, Yuan F, Liang H, Rong Y (2014) The effects of grazing management strategies on the vegetation, diet quality, intake and performance of free grazing sheep. *Livestock Science* 161, 185–192.

Parsons D, Nicholson CF, Blake RW *et al*. (2011) Application of a simulation model for assessing integration of smallholder shifting cultivation and sheep production in Yucatan, Mexico. *Agricultural Systems* 104, 13–19.

Takahashi T, Jones R, Kemp D (2011) Steady-state modelling for better understanding of current livestock production systems and for exploring optimal short-term strategies. In. *Development of Sustainable Livestock Systems on Grasslands in North-western China, ACIAR Proceedings No. 134* (Eds Kemp DR, Michalk DL), pp.26–35. (Australian Centre for International Agricultural Research, Canberra)

Zheng C, Liu Y, Bluemling B, Chen J, Mol APJ (2013) Modelling the environmental behaviour and performance of livestock farmers in China: an ABM approach. *Agricultural Systems* 122, 60–72.