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Quantifying the economic value of evidence-based animal selection on the inner Mongolian desert steppe

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Introduction

Inner Mongolian desert steppe in northwestern China suffers from significant grassland degradation, causing a decrease in producers' income as well as negative off-site impacts (Kemp *et al*., 2013). Recent studies attribute this problem to a sudden increase in the stocking rate over the last half century, and thus development of an alternative farming system to reduce the animal number is urgently needed (Wang *et al*., 2011). Scientific experiments and modelling analyses have shown the potential of innovative systems that could deliver a "win-win" solution to local producers and environment (Li *et al*., 2015). However, the uptake of the proposed new technologies is generally slow because of the scepticism amongst producers, which is often augmented by the traditional herding culture whereby a large flock of animals is a symbol of social success (Kemp and Michalk, 2007).

The objective of the present paper is to quantify the economic value of evidenced-based ewe selection, vis-à-vis random selection, the former of which could reduce the negative economic impact to producers due to the reduced stocking rate or, in some cases, even improve their long-term income (Kemp *et al*., 2011). A particular attention is paid to the carryover effect of an ewe's body condition at an early stage of pregnancy on her lamb's bodyweight at the annual sales time, a relationship relatively understudied in the preceding literature. Because lambs' bodyweight is the most closely linked to economic benefits enjoyed by local producers specializing in meat production, a positive result from this study would be valuable information to convince them to adopt an alternative farming strategy.

Materials and Methods

The research was conducted in Siziwang Banner in China's Inner Mongolia Autonomous Region. With elevation of around 1400 m, Siziwang's climate is characterized as continental: windy in spring, low precipitation in summer, and dry and cold throughout winter. The annual average temperature is 4.1 °C, whilst precipitation and evaporation are 305 mm and 2213 mm, respectively. The frost-free period is 175 d/yr (Li *et al*., 2015).

The entire flocks of sheep from two actual farms were monitored throughout the year from September 2008 to August 2009. All mothers were weighed on 11 and 12 December, at the beginning of the harsh winter and approximately two months after the local joining period. Their fat score, teeth number (as a proxy variable for age), teeth condition (for efficiency in pasture consumption) and udder condition (for lactation potential) were also checked on this occasion. As lambs were born, they were matched with their mothers using the ear tags. The matching process was finalized on 29 and 30 March. After weaning, the bodyweight of both mothers and lambs was measured twice, on 4 and 5 July and on 20 and 21 August. These dates were selected so as to coincide with the end of the pasture growth period and the traditional lamb sales, respectively.

Of the two farms monitored in this study, one farm (Farm 1) followed the traditional practice for animal and pasture management, while the other (Farm 2) adopted a package of improved practice outlined by Kemp *et al*. (2011). The package included changes in grazing hours and in the ration of supplementation, and a very moderate reduction of the stocking rate. As a result, Farm 2 had a slightly lower number of adult ewes (82) than Farm 1 (101) at the conclusion of the lambing period.

The multivariate regression analysis was conducted to test the causal relationship between the lamb's bodyweight in July and August and the ewe's body condition in December. The effects of multiple births (twins and triplets) and the timing of the birth were also considered. Finally, the total economic value of lambs for a given flock size was computed for each

farm based on two different animal selection strategies: random culling and evidenced-based culling. The expected value from random culling was computed by the Monte Carlo approach with repeated subsampling. For evidenced-based culling, the ewe's bodyweight in December was used as the benchmark to rank the animals. These processes were repeated for the entire range of the possible flock sizes, from the situation to cull all but one animal to the situation with no culling. Because local producers in the study area are paid for the total liveweight of lambs sold, all economic values were expressed in the unit of cumulative weight (kg) of lamb sales. This treatment makes the analysis robust to price fluctuations.

Results and Discussion

Table 1 summarises the results of the multivariate regression that yielded the best overall fit. According to this specification, a 1 kg increase in the ewe's bodyweight contributes to a .23 kg of additional sales weight of the lamb. Each twin is only lighter by 4.9 kg than singles, suggesting that multiple births can significantly enhance the value of the sold animals. A 10-day difference in the timing of birth results in a .5 kg difference for lambs although, unlike other factors that are controllable through farming practices, this is mostly the result of a random process. Other things being equal, lambs from Farm 2 are 6.3 kg heavier than those from Farm 1, supporting the income effect of the altered farming system discussed by Kemp *et al*. (2011).

The regression for lambs' bodyweight in July showed similar results, with a slightly higher coefficient (.28) for the effect of the ewe's bodyweight (results not shown). This small difference may have stemmed from the compensatory gain by lighter animals towards the end of the summer, although this hypothesis is yet to be confirmed. The effect of the ewe's fat score, teeth number, teeth condition or udder condition was statistically insignificant (results not shown).

Table 1. Results of the regression

$$\underset{}{lweight} = \underset{}{23.16} + \underset{(3.72)}{.23}\,eweight - \underset{(1.21)}{4.91}\,nlambs - \underset{(.01)}{.05}\,bdate + \underset{(.94)}{6.26}\,farm \quad \underset{(.06)}{}$$

lweight: bodyweight of the lamb at the sales time
eweight: bodyweight of the ewe at the beginning of the previous winter
nlambs: number of lambs born to the mother of the lamb
bday: date of birth of the lamb in Julian day
farm: fixed effect for Farm 2

Numbers in parentheses are standard errors of the estimators. All estimators are statistically significant at the .1% level ($p < .001$). $N = 167$.

Fig. 1 shows the cumulative economic value of lambs for Farm 1 under the two culling strategies. The figure demonstrates that regardless of the flock size, the evidenced-based culling of mothers in winter results in a higher lamb sale in the following summer. The relative value of selective culling is particularly high when around one-third of the existing ewes are chosen to be culled, whereby each lamb is nearly 1 kg or 3% heavier at the sales time than under random culling. The results for Farm 2 were similar (results not shown). Given that the present form of the evidenced-based selection involves virtually no additional cost to producers, the above results may help convince them to reduce their stocking rate to a more sustainable level such as the one suggested by Li *et al.* (2015).

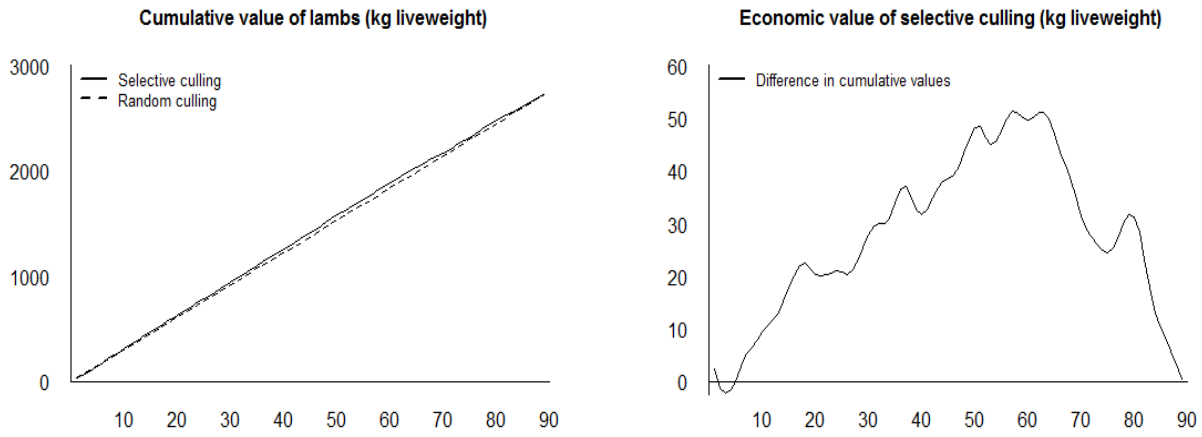

Fig. 1: Cumulative value of lambs under different culling rules (left) and their difference (right)

Conclusion

The present study has demonstrated that ewes' body condition at an early stage of pregnancy affects lambs' bodyweight at the sales time and can be used as a basis for strategic animal selection. Reducing the animal number has a further carryover effect in the form of improved pasture growth and pasture composition, the details of which were not studied here. A method to also quantify these effects, particularly through the use of a biophysical model with heterogeneous animals, is currently being investigated.

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