Manipulation of the Spatial Grazing Behaviour of Livestock in Extensive Grassland Systems

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Manipulation of the spatial grazing behaviour of livestock in extensive grassland systems

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Abstract. Spatial behaviour of livestock is a critical factor in grassland management. Recent and ongoing research suggests that new approaches can be used to manipulate where cattle graze. The combination of strategic supplement placement and low-stress herding can be used to target cattle grazing and potentially may be useful for managing fine fuels. A phenotype to genotype association study of cattle spatial behavior suggests that use of rugged terrain and areas far from water is inherited. Although more research is needed, selection for animals specifically adapted for mountainous terrain or extensive paddocks may be an alternative for managing grasslands in the near future.

Keywords: Distribution, selection, supplement, cattle, water, GPS tracking.

Introduction

Stocking rate, timing of grazing, animal type and distribute-ion are the four principles of grazing management (Vallentine 2001). In arid and semi-arid grasslands, water availability often limits grazing distribution in extensive paddocks and forage utilization decreases with increasing distance from water (Valentine 1947). Mountainous terrain also constrains where livestock graze. Cattle readily use gentle slopes (<10%) but avoid steep (>30%) slopes (Mueggler 1965; Holechek 1988). Vertical distance to water has been found to be critical for determining where cattle graze in rugged terrain (Roath and Krueger 1982). Also, Holechek (1988) recommended excluding steep slopes and areas farther than 3.2 km from water during stocking rate calculations, because typically livestock spend little time grazing in these areas. Correspondingly, management that increases use of rough topography and areas distant from water can reduce overgrazing of prefer-ed areas and/or sustainably increase stocking levels. Manipulation of spatial grazing patterns also may help alleviate effects of drought if livestock can be encouraged to use areas that they typically avoid.

Almost all of the tools we currently use to manipulate spatial grazing behaviour of livestock have been known for nearly 60 years (Williams 1954). However, recent advances in global positioning system (GPS), geographic information system (GIS) and genomic research technologies have allowed us to study in-depth management practices and evaluate the underlying behavioral mechanisms. The objective of this presentation is to discuss recent and ongoing research that uses novel approaches to understand and manipulate the spatial behaviour of livestock.

Targeting Cattle Grazing

Strategic placement of supplement in areas that receive little grazing can be a useful tool for manipulating spatial grazing behaviour. Cattle are attracted to the supplement even though it may be in rugged terrain or areas far from water. After walking to the supplement placement site, travel to nearby areas is minimal. Low-moisture block protein (LMB) supplements are more effective in manipulateing spatial behaviour of cattle than salt or salt mineral mixes (Bailey and Welling 2007; Bailey *et al.* 2008a). However, a salt-mineral mix was effective in luring cattle to steep terrain in the western region of the Italian Alps (Probo *et al.* 2013).

Pastoralists have used herding to direct livestock spatial behavior for centuries. However, development of low-stress livestock handling techniques has improved our ability to direct where cattle graze and does not require herders to continuously remain with the animals. Low-stress livestock handling has been defined as follows (Hibbard 2012): "A livestock-centered, behaviorally-correct, psychologically-oriented, ethical and humane method of working livestock which is based on mutual communication and understanding." Herding cattle away from streams using low-stress livestock handling tech-niques is an effective method of protecting stream-banks and riparian areas (Bailey *et al.* 2008b). Low stress livestock herding combined with strategic LMB placement can be used to target cattle grazing. Cattle tend to remain near LMB supplement if intake is near recommended levels (Fig. 1). Consumption of LMB helps ensure cattle remain in target areas after herding. If forage is actively growing or if cattle do not readily consume supplement, animals

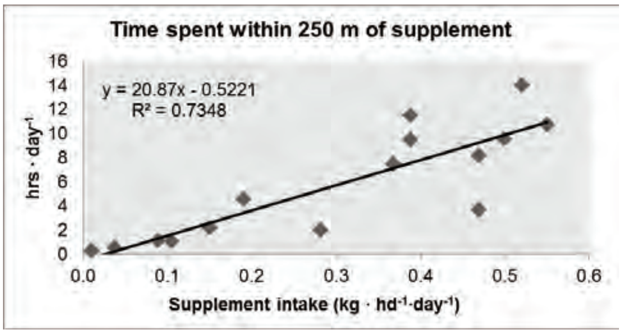

Figure 1. Relationship between time spent within 250 m of supplement (target area) and intake of low-moisture block supplement. This summarizes 5 studies conducted in Arizona and New Mexico.

may not stay within the target area. Joint research conducted in a mountainous area in Arizona showed that cattle could reduce herbaceous standing crop (fine fuels) from 1500 kg/ha to 820 kg/ha in target areas located in steep terrain and 1 to 3 km from water (Bruegger 2012). Research conducted in New Mexico showed that herbaceous fine fuels could be reduced from 1780 kg/ha to 990 kg/ha in target areas located over 2 km from water. Such reductions in fine fuels can reduce flame heights and reduce rate of fire spread sufficiently to potentially reduce costs of firefighting based on fire behavior models (Varelas 2012).

Development of Adapted Animals

Cattle can have very different grazing patterns with "hill-climber" cows naturally using higher elevations, steeper slopes and areas far from water, while "bottom dweller" cows use gentle terrain near water (Bailey *et al.* 2004). One approach to manipulate spatial behavior of livestock is to select for hill climber cattle and cull bottom dwellers (Roath and Krueger 1982; Bailey 2005). One potential criticism of this approach is that hill climbers may no longer use rugged terrain after bottom dwellers are culled. However, Bailey *et al.* (2006) found that differences in grazing patterns between hill climber and bottom dweller cows continued even after these two groups were separated.

For genetic selection of cattle for spatial behavior to be practical and cost effective, this trait must be heritable (*i.e.*, estimable portion of phenotypic variance is due to genetics). Training can dramatically change animal behavior, but it is labor intensive and often costly. In addition, genetic progress of culling cows results in much less progress than sire selection. Our research team conducted the first genotype to phenotype association study of difficult to measure quantitative production traits that are important for rangeland sustainability. A total of 87 cows were tracked for 1 to 3 months in mountainous and/or extensive rangeland pastures at 5 ranches located in New Mexico, Arizona and Montana. DNA was collected from these cows and analyzed using the Illumina Bovine SNPHD array, which evaluates approximately 770,000 genetic markers (*i.e.*, single nucleotide polymorphisms; SNP) across the 30 bovine chromosomes. The GPS data were used to characterize use of rough terrain and areas far from water using indices based on the normalized averages of slope use, elevation use, and distance to water. A chromosome region associated with these traits is known as a quantitative trait locus (QTL) and the significance is determined by the statistical association of genotypes with phenotype effects (log10 p-value>5). Significant QTL regions were detected on chromosomes 17 and 29 for slope and elevation. When these variables were combined with distance to water, QTL were detected on 11 chromosomes and a structural copy number variant was detected on chromosome 8. A QTL region can span many base-pairs on a chromosome and encompass numerous genes. However, QTL analyses are a useful entry-point for identifying functional loci and potential genetic markers to help understand the genetic and physiological basis of cattle grazing distribution. One genetic marker on chromosome 29 overlaid a gene that appears to be a factor in feeding behavior, appetite and locomotion based on our physiological knowledge of its function. This location accounted for 25% of the phenotypic variation in use of steep slopes and high elevations. A variant of this gene appears to be extremely useful for identifying hill climbers. The QTL on chromosome 17 accounted for 21% of the phenotypic variation in slope and elevation use. Additional QTL were found on other chromosomes and accounted for 5 and 10% of the variation in slope and elevation use as well as distance travelled from water. These findings are very exciting and exceeded our expectations. Most individual genetic markers account for only 1 or 2% of the phenotypic variation in a trait (Garrett *et al.* 2008; DeAtley *et al.* 2011; Luna-Nevarez *et al.* 2011). These data clearly show that spatial grazing behavior is inherited. Heritability is the proportion of the phenotypic variance accounted for by genetic variance. Based on our preliminary data, slope and elevation use may have a heritability of 25% or greater, similar to heritability of weaning weight in cattle which varies from 20% to 35% (Koots *et al.* 1994).

The next step is to develop and evaluate a SNP panel designed to identify the genotypes associated with QTL for grazing distribution. Such a panel could be used to identify cattle with superior genotypes for spatial behaviour for a cost under $25 USD. With this information, a genomic estimated progeny difference (EPD) program can potentially be developed to give cattlemen a selection tool for distribution. This ongoing research suggests that development of cattle that are specifically adapted to extensive and/or rugged pastures may be feasible within the foreseeable future.

Conclusions

Except during periods of active forage growth, the combination of strategic supplement placement and low-stress herding can be used to target cattle grazing in areas far from water and in rough terrain. Such targeted grazing may be useful in managing prescribed fire as well as wildfires. Spatial behavior of cattle appears to be heritable and superior genotypes may potentially be identified by DNA tests. Selection of cattle for spatial grazing behaviour may be viable management option in the near future.

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References

Bailey DW (2005) Identification and creation of optimum habitat conditions for livestock. *Rangeland Ecology and Management* **58**, 109-118.

Bailey DW, Keil MR, Rittenhouse, LR (2004) Research observation: Daily movement patterns of hill climbing and bottom dwelling cows. *Journal of Range Management* **57**, 20-28.

Bailey DW, VanWagoner HC, Weinmeister, R (2006) Individual animal selection has the potential to improve uniformity of grazing on foothill rangeland. *Rangeland Ecology and Management* **59**, 351-358.

Bailey DW, VanWagoner HC, Weinmeister R, Jensen D (2008a) Comparison of low-moisture blocks and salt for manipulating grazing patterns of beef cows. *Journal of Animal Science* **86**, 1271-1277.

Bailey DW, VanWagoner, HC, Weinmeister R, Jensen D (2008b) Evaluation of low-stress herding and supplement placement for managing cattle grazing in riparian and upland areas. *Rangeland Ecology & Management* **61**, 26-37.

Bailey DW, Welling GR (2007) Evaluation of low-moisture blocks and conventional dry mixes for supplementing minerals and modifying cattle grazing patterns. *Rangeland Ecology and Management* **60**, 54-64.

Bruegger R (2012) Use of targeted grazing in Arizona to accomlish rangeland management goals and herder observations of indicators and causal factors influencing rangeland change in Mongolia. M. S. Thesis thesis, University of Arizona.

DeAtley KL, Rincon G, Farber CR, Medrano JF, Luna-Nevarez P, Enns RM, VanLeeuwen DM, Silver GA, Thomas MG (2011) Genetic analyses involving microsatellite ETH10 genotypes on bovine chromosome 5 and performance trait measures in Angus- and Brahman-influenced cattle. *Journal of Animal Science* **89**, 2031-41.

Garrett AJ, Rincon G, Medrano JF, Elzo MA, Silve GA, Thomas MG (2008) Promoter region of the bovine growth hormone receptor gene: single nucleotide polymorphism discovery in cattle and association with performance in Brangus bulls. *Journal of Animal Science* **86**, 3315-23.

Hibbard W (2012) Low-stress livestock handling: Mapping the territory. *Stockmanship Journal* **1**, 10-30.

Holechek JL (1988) An approach for setting the stocking rate. *Rangelands* **10(1)**, 10-14.

Koots KR, Gibson JP, Smith C, Wilton JW (1994) Analyses of published genetic parameter estimates for beef production traits. 1. Heritability. *Animal Breeding Abstracts* **62**, 309-338.

Luna-Nevarez P, Rincon G, Medrano JF, Riley DG, Chase CC Jr., Coleman SW, Vanleeuwen DM, DeAtley KL, Islas-Treo A, Silver GA, Thomas, MG (2011) Single nucleotide polymorphisms in the growth hormone-insulin-like growth factor axis in straightbred and crossbred Angus, Brahman, and Romosinuano heifers: population genetic analyses and association of genotypes with reproductive phenotypes. *Journal of Animal Science* **89**, 926-34.

Mueggler WF (1965) Cattle distribution on steep slopes. *Journal of Range Management* **18**, 255-257.

Probo M, Massolo A, Lonati M, Bailey D, Gorlier A, Maurino L, Lombardi G (2013) Use of mineral mix supplements to modify the grazing patterns by cattle for the restoration of sub-alpine and alpine shrub-encroached grasslands. *Rangeland Journal*

Roath LR, Krueger WC (1982) Cattle grazing and behavior on a forested range. *Journal of Range Management* **35**, 332-338.

Valentine KA (1947) Distance from water as a factor in grazing capacity of rangeland *Journal of Forestry* **45**, 749-754.

Vallentine JF (2001) 'Grazing Management.' (Academic Press: San Diego, CA)

Varelas LA (2012) Effectiveness and costs of using targeted grazing to alter fire behavior. M. S. Thesis thesis, New Mexico State University.

Williams RE (1954) Modern methods of getting uniform use of ranges. *Journal of Range Management* **7**, 77.