Manipulation of the spatial grazing behaviour of cattle in extensive and mountainous rangelands

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Abstract

Spatial behaviour of livestock is a critical factor in rangeland management. Ongoing research suggests that new approaches can be used to manipulate where beef cattle graze in extensive or rugged rangeland pastures. 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 grazing distribution 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 pastures may be an option for improving grazing management in the near future.

Keywords: Distribution, selection, supplement, genomics, water, GPS tracking

Introduction

Stocking rate, timing of grazing, animal type and distribution are the four principles of grazing management (Vallentine, 2001). In arid and semi-arid grasslands, water availability often limits grazing distribution in extensive pastures, 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). Roath and Krueger (1982) found that vertical distance to water is critical for determining where cattle graze in rugged terrain. 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 preferred 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 almost 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 the underlying behavioral mechanisms associated with distribution practices. The objective of this presentation is to discuss our recent and ongoing research, which uses novel approaches to understand and manipulate the spatial behaviour of beef cattle.

Targeting Cattle Grazing

Strategic placement of supplement in areas that receive little grazing can be a useful tool for manipulating grazing distribution. Cattle are attracted to supplement even if it is placed in rugged terrain or areas far from water. After walking to the supplement placement site, effort required to travel to nearby areas is minimal. Low-moisture block protein (LMB) supplements are more effective for managing cattle grazing patterns 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 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 (Hibbard, 2012). Herding cattle away from streams using low-stress livestock handling techniques is an effective method for protecting 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 (Figure 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 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).

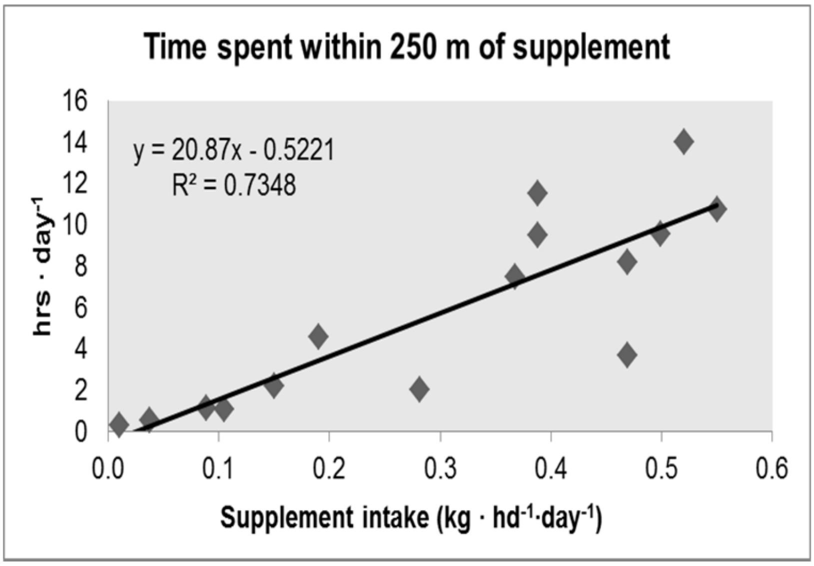

Figure1: Relationship between time spent within 250 m of supplement (target area) and intake of low-moisture block supplement. This summarizes 5 studies conducted in Arizona and New Mexico.

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 genetically 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 behaviour to be practical and cost effective, this trait must be heritable (i.e., estimatable 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 may be useful for identifying hill climbers. The QTL on chromosome 17 accounted for 21% of the phenotypic variation in slope and elevation use. Additional QTL found on other chromosomes 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, because 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).

Using the results from the Illumina Bovine SNPHD array, a smaller panel based on 50 SNP was developed and evaluated on the 87 cows tracked previously and an additional 73 cows from 4 ranches in Arizona and New Mexico (n=160 cows at 7 ranches). Multiple genetic markers near or within the gene identified on chromosome 29 were associated with indices of terrain use and accounted for 10 to 18% of the phenotypic variation. In addition, a marker on chromosome 4 accounted for 26% of the variation in an index based on use of steep slopes, high elevations and areas far from water. Other QTL on chromosomes 8, 12 and 17 accounted for 10 to 15% of the phenotypic variation in indices of terrain use. Results from this evaluation of 50 selected SNP near candidate genes and QTL support the analyses from the Illumina Bovine SNPHD array. The association between indices of terrain use and multiple genetic markers near candidate genes clearly shows that grazing distribution and spatial behavior of cattle is a heritable trait.

A SNP panel designed to identify the genotypes associated with QTL for grazing distribution (similar to the one described above) could be used to identify cattle with superior genotypes for grazing distribution. With this type of information, a genomic estimated progeny difference (EPD) program can potentially be developed to give cattlemen a selection tool for grazing 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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