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Relationship of pulmonary arterial pressure and terrain use of Angus cows grazing high-altitude foothill rangelands

Derek W. Bailey [a,*], Milton G. Thomas [b], Tim N. Holt [c], Mitch B. Stephenson [a,d], R. Mark Enns [b], Scott E. Speidel [b]

[a] Department of Animal and Range Sciences, New Mexico State University, Las Cruces, NM 88003, United States
[b] Department of Animal Science, Colorado State University, Fort Collins, CO 80523, United States
[c] Department of Clinical Sciences, Colorado State University, Fort Collins, CO 80523, United States
[d] Panhandle Research and Extension Center, University of Nebraska-Lincoln, Scottsbluff, NE 69631, United States

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ABSTRACT

Pulmonary arterial pressure (PAP) score is used as an indicator trait for risk of hypoxia-induced pulmonary hypertension, which is commonly termed high altitude disease and observed in cattle grazing at altitude ≥1500 m. We hypothesized that cows with higher PAP score would avoid using high elevations, steep slopes and areas far from water while grazing foothill rangeland. During 2013 and 2014, forty-one mature Angus cows from a breeding population of cattle selected for tolerance to high altitude were tracked with global positioning system (GPS) collars for 27 and 17 days, respectively. These cows grazed a 1210 ha foothill rangeland pasture with a vertical relief of 2150–2411 m. Pulmonary arterial pressure was measured for each animal at 1 year of age (yearling PAP; 38.2 mm Hg ± 5.1 SD mm Hg) and before tracking (mature PAP; 42.6 mm Hg ± 3.7 SD). Yearling PAP score was not correlated with the mature PAP score ($r=0.23$, $P=0.15$). Terrain use varied among individual tracked cows, and the range among cows within the same pasture was 59 m (2204 m ± 15 SD) for average elevation use, 4.7% points (8.9% ± 0.2 SD) for average slope use and 247 m (446 m ± 77 SD) for average distance from water. No correlation was detected between mature PAP scores and terrain use metrics (mean elevation, slope and distance from water of tracked locations; $r=-0.16$, 0.24, 0.25; $P>0.10$). Similarly, no correlation was detected ($P>0.10$) between yearling PAP score and terrain use metrics. Yearling and mature PAP scores were not correlated ($P>0.50$) to indices of terrain use that combined elevation and slope use (rough index) and elevation, slope and distance from water (rolling index). Yearling PAP and mature PAP were not useful predictors ($P>0.10$) of terrain use in multiple regression analyses. Angus cows in this study were apparently adapted to high elevations and PAP score had little, if any, relationship with their metrics of grazing distribution of foothill rangeland. In situations where elevation was higher, terrain was more rugged or cattle were not adapted, results may differ from those observed in this study.

1. Introduction

It is common for cattle to graze at elevations ≥1500 m during at least part of the year in the western United States. In these production environments, high altitude disease has been documented for at least a century (Glover and Newsom, 1917; Salman et al., 1991). This disease is caused by pulmonary hypertension, which is measured by pulmonary arterial pressure (PAP). Cattle with PAP scores greater than 50 mm Hg are considered at risk for developing pulmonary hypertension and its consequential disease phenotypes (Holt and Callan, 2007). Pulmonary arterial pressure score has been determined to be a moderate to highly heritable trait ($h^2=0.20$–0.40) in yearling cattle, and therefore useful in the selection of breeding cattle for high elevation beef production systems (Enns et al., 1992; Shirley et al., 2008; Cockrum et al., 2014). However, there are examples where calf mortalities remain above normal at high elevation ranches despite selection for low PAP scores for several decades (Neary et al., 2013a, 2013b; 2015a, 2015b).

Grazing distribution is a critical issue for cattle ranchers using extensive and rugged rangelands typically used in high elevation, mountainous beef production systems. Cows typically avoid steep slopes (Mueggler, 1965) and areas far from water (Valentine, 1947; Roath and Krueger, 1982). Many management practices designed to improve grazing distribution, such as water developments and

* Corresponding author.
E-mail addresses: dwbailey@nmsu.edu (D.W. Bailey), Milt.Thomas@colostate.edu (M.G. Thomas).

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herding, are expensive and (or) labor intensive (Bailey, 2004). Selection and (or) culling has been described as a potential, cost effective approach to improve grazing distribution (Roath and Krueger, 1982; Howery et al., 1996; Bailey et al., 2006). Cattle grazing distribution was associated with multiple genetic markers and appears to be a heritable trait (Bailey et al., 2015). This recent finding increases the potential for genetic selection and identifying bulls that will likely sire daughters that use rough terrain. To implement a successful selection program, a thorough understanding of grazing distribution traits and its potential trait antagonisms are needed. The objective of this study was to evaluate the relationship between PAP score and metrics of terrain use of beef cows grazing a high-elevation foothill rangeland pasture. We hypothesized that cows with higher PAP score would avoid high elevations or steep slopes. We also expected cows with higher PAP scores would not travel as far from water or walk as far each day as cows with lower PAP values in a high elevation beef production system.

2. Materials and methods

2.1. Study site and cattle

The study was conducted at the Colorado State University Beef Improvement Center (i.e., One Bar Eleven Ranch) located 14 km east of Encampment, WY. Angus cows grazed in the United States Forest Service Beaver Hills Allotment (latitude 41° 14.9′, longitude 106° 38.8′ W). This native grass-sagebrush rangeland pasture consisted of 1210 ha, and the elevation ranged from 2150 to 2411 m. The average elevation was 2228 m. Slopes varied from 0 to 72% with an average slope of 12%. The average and maximum distance from water was 679 and 1755 m, respectively. Cattle grazed and were tracked in the Beaver Hills Allotment pasture from May 19 to June 14 during 2013 and from May 19 to June 4 during 2014. Cattle were tracked with Lotek GPS 3300 collars (Newmarket, Ontario, Canada). Positions were recorded at 10-min intervals. Similar to Ganskopp and Johnson (2007), our evaluations indicate that the GPS collars were accurate within 5–7 m. Other researchers have recorded similar accuracies for Lotek GPS 3300 collars when operating in non-forested terrain similar to this study site (Lewis et al., 2007; Hansen and Riggs, 2008).

Cattle in the study were mature purebred Angus cows with calves of the Colorado State University Beef Improvement Center breeding herd (n=430 cows), which is an agricultural experiment station breeding population where cattle are selected for tolerance and performance in a high elevation beef production system. In 2013, nineteen 8 year-old cows were tracked, and in 2014, twenty-two 5-year old cows were tracked. The age groups of cows that were used in the study had the greatest variance in yearling PAP scores compared to other age groups of mature cows in the herd at this time. Variance of yearling PAP for cow age groups used for tracking in 2013 and 2014 were 34.7 (n=26 cows) and 21.6 (n=27 cows), respectively. Within a selected age group, cows with similar aged calves were selected for tracking in order to minimize potential confounding of calf age and terrain use of cows. Average weight of the tracked cows was 552 ± 7.0 kg, and average body condition score (BCS) was 4.8 ± 0.1 using a beef cattle scale of 1–9, where 1 is emaciated and 9 is obese (Mathis et al., 2002). The tracked cows comingled in a herd of approximately 300 Angus cow-calf pairs during both 2013 and 2014. All cows in the Beaver Hills allotment pasture had spring-born (March to April in northern hemisphere) calves that were 3.1 ± 0.3 months of age during the tracking period.

2.2. Pulmonary arterial pressure

The PAP score of each cow was measured when they were approximately 12 months of age (yearling PAP) and again approximately 2 weeks prior to GPS tracking (mature PAP). The PAP measures were collected by a Colorado licensed veterinarian using the procedures of Holt and Callan (2007). In brief, a catheter was inserted into the jugular vein and maneuvered through the right atrium and ventricle into the pulmonary artery. A pressure transducer and data-oscilloscope capable of measuring invasive blood pressure were used to record PAP in mm Hg. This type of system records systolic, diastolic, and mean PAP pressures. For this study, mean PAP score was used as the indicator of cardio-pulmonary status and PAP scores >50 mm Hg signified cattle at risk for developing high altitude disease.

2.3. Terrain use metrics

A digital elevation model (DEM) was obtained from the USGS Seamless Data Warehouse (seamless.usgs.gov) for the Beaver Hills Allotment pasture. The DEM was used to provide an elevation for each recorded position using the Spatial Analyst Extension in ArcMap tools (ArcGIS software, Redlands, CA, www.esri.com). Similarly percent slope was derived from the DEM for each collar position. Watering point locations (artesian-springs and available sections of Beaver Creek) were used to determine the distance from water for each collar position. The average elevation for each cow was calculated from all recorded positions for that cow during the tracking period. Similarly, the average slope and distance from water for each cow was calculated from all positions recorded during the tracking period.

Individual cows from each year of tracking were ranked by an index identified as “rough” which is a “normalized average” of elevation and slope (Bailey et al., 2015). The mean elevation of each cow was divided by average elevation use of all cows tracked at the Rouse Ranch during that tracking period and multiplied by 100. Similarly, mean slope use of each cow was divided by the average slope use of all cows tracked at a study site and multiplied by 100. The corresponding products associated for elevation and slope for each cow were then averaged.

$$\text{Rough Index} = \left(\left(\text{slope}_k/\text{slope}_l\right)*100\right) + \left(\left(\text{elevation}_k/\text{elevation}_l\right)*100\right)/2$$

Where; k was the respective mean of a collared cow and l was the respective mean of all collared cows during a given tracking period.

The rough index reflected relative differences in elevation and slope use. A value of 100 indicated that the mean elevation and slope use for that cow was equivalent to the average of all tracked cows. Values less than 100 corresponded to gentler and/or lower terrain use than average, and values over 100 indicated use of steeper slopes and/or higher terrain.

An index termed “rolling” was used to evaluate a combination of elevation, slope, and distance to water (Bailey et al., 2015). Mean values of each cow for these variables were divided by corresponding averages of all tracked cattle at the study site during the entire tracking period and then multiplied by 100. These corresponding ratio variables were then averaged together.

$$\text{Rolling Index} = \left(\left(\text{slope}_k/\text{slope}_l\right)*100\right) + \left(\text{elevation}_k/\text{elevation}_l\right)*100) + \left(\text{distance from water}_k/\text{distance from water}_l\right)/3$$

Where; k was the respective mean observation of a collared cow