

Grazing behavior and production for cattle on differing late-season rangeland grazing systems with or without protein supplementation

James E. Sprinkle,^{†,‡,1} Joseph K. Sagers,^{||} John B. Hall,^{†,‡} Melinda J. Ellison,^{†,‡} Joel V. Yelich,[‡]
Jameson R. Brennan,[§] Joshua Bret Taylor,^{¶,•} and James B. Lamb^{**}

[†]Department of Animal and Veterinary Sciences, University of Idaho, Moscow, ID 83844; [‡]University of Idaho, Nancy M. Cummings Research, Extension and Education Center, Carmen, ID 83462; ^{||}University of Idaho, Jefferson and Clark County Extension, Rigby, ID 83442; [§]West River Ag Center, South Dakota State University, Rapid City, SD 57702; [¶]U.S. Sheep Experiment Station, USDA Agricultural Research Service, Dubois, ID 83423; and [•] and ^{**}Furst-McNess Company, Rexburg, ID 83440

© The Author(s) 2019. Published by Oxford University Press on behalf of the American Society of Animal Science. This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact journals.permissions@oup.com

Transl. Anim. Sci. 2019.3:1792–1796
doi: 10.1093/tas/txz100

INTRODUCTION

Cows maintained on late-season rangeland in the Pacific Northwest often experience declining forage quality which may fail to meet protein requirements (7% of dry matter) necessary for adequate rumen function (Leng, 1990).

Earlier research (Sprinkle et al., 2016) suggested that 2-yr-old cows ranked as efficient (low-residual feed intake; LRFI) may experience less body condition and weight loss than cows ranked as inefficient (high-residual feed intake; HRFI) when grazing late-season rangeland.

The objectives of this study were to determine if 1) mixed-age cattle with or without protein supplement on either a continuous or rotational late-season rangeland grazing system differed in BW, and 2) 2-yr-old LFRI vs. HFRI cattle on the same pasture and supplementation treatments altered grazing behavior depending upon RFI classification, supplementation status, or pasture treatment. Our hypothesis was that cattle with greater nutritional demands would express this by searching more for a quality diet, thus reducing resting time and increasing walking time.

MATERIALS AND METHODS

Treatment Allocation

All procedures were approved by the University of Idaho Animal Care and Use Committee (IACUC no. 2015-44).

In 2016 and 2017, Hereford × Angus cattle were allocated to one of four treatments: 1) grazed same pasture with no protein supplementation (CCON, $n = 75$); 2) grazed same pasture with 3.17 kg Bova Cubes (28% crude protein dried distillers grain protein cube; Furst-McNess Company, Freeport, IL) per cow fed once a week (CTRTR, $n = 71$); 3) grazed rotated pastures (13 pastures in 2016, 2 pastures in 2017) with no protein supplementation (RCON, $n = 73$); or 4) grazed rotated pastures (13 pastures in 2016, 2 pastures in 2017) with 3.17 kg Bova Cubes fed as described earlier (RTRTR, $n = 73$). The protein supplement was fed once a week at approximately 1200 hours.

Range Sites

The trials were conducted from mid-October to mid-December in 2016 and 2017 at the U.S. Sheep Experiment Station (USSES), located about 16 km northeast of Dubois, Idaho (112°7'W, 44°18'N). In 2016, 44 CCON cows

¹Corresponding author: sprinkle@uidaho.edu

Received April 4, 2019.

Accepted June 8, 2019.

grazed a 359-ha pasture; 42 CTRT cows grazed a 1,381-ha pasture; 25 RCON cows grazed 13 ten-ha small pastures, moving every 3 to 4 d; and 25 RTRT cows also grazed similar small pastures. In 2017, 31 CCON cows grazed a 90-ha pasture; 29 CTRT cows grazed a 79-ha pasture; 48 RCON cows grazed a 65-ha pasture and then another 65-ha pasture, moving after 25 d; and 48 RTRT cows grazed a 65-ha pasture and then another 65-ha pasture, moving after 25 d.

Range sites were within the sagebrush steppe with elevations ranging from 1,740 to 1,867 m in 2016 and from 1,659 to 1,699 m in 2017. Slopes were generally <20% but mostly between 0% and 12%. The mean annual precipitation (1981 to 2010) near the research sites (112°12'W, 44°15'N, elevation, 1,661 m) is 328 mm with 58% occurring during April through September. Pastures are dominated by mountain big sagebrush (*Artemisia tridentata* Nutt. ssp. *vaseyana* [Rydb.] Beetle) and threetip sagebrush (*Artemisia tripartita* Rydb.) with subdominant shrub species including antelope bitterbrush (*Purshia tridentata* [Pursh] DC.), yellow rabbitbrush (*Chrysothamnus viscidiflorus* [Hook.] Nutt.), and spineless horsebrush (*Tetradymia canescens* DC.). Dominant perennial grasses include Great Basin wildrye (*Leymus cinereus* [Scribn. & Merr.] A. Löve), Idaho fescue (*Festuca idahoensis* Elmer), sandberg bluegrass (*Poa secunda* Presl), thickspike wheatgrass (*Elymus lanceolatus* [Scribn. & J.G. Sm.] Gould ssp. *lanceolatus*), bluebunch wheatgrass (*Pseudoroegneria spicata* [Pursh] A. Löve ssp. *spicata*), and plains reedgrass (*Calamagrostis montanensis* Scribn. ex Vasey) with only trace amounts of annual cheatgrass (*Bromus tectorum*). The dominant forb is silvery lupine (*Lupinus argenteus* Pursh).

Animal Measurements

Previous to this trial, all 2-yr-old cows used for grazing behavior were classified as LRFI or HRFI as yearling heifers as described by Hall et al. (2015).

In 2016, 104 pregnant, non-lactating cattle were allocated to treatment pastures on October 18 and 32 cattle on October 24. Beginning BW was obtained and a subset of 2-yr-old cows (12 LRFI, 12 HRFI) were fitted with custom-made grazing halters containing both a 3-axis accelerometer (USB Logger Model XB; Gulf Coast Data Concepts, LLC, Waveland, MS) and a global-positioning-system (GPS) logger (i-gotU GT-120, Mobile Action Technology, New Taipei City,

Taiwan). Both the accelerometer and the GPS logger had a rechargeable Li-ion 3.7-V, 5,200-mAh battery (Tenery Li-ion 18650, Fremont, CA) soldered to the equipment to extend data logging. There were three LRFI and three HRFI cows placed within each pasture treatment. On November 17, BWs were obtained and grazing halters removed. On December 13, cows were shipped to the University of Idaho Nancy M. Cummings Research, Extension and Education Center at Carmen, Idaho (113°52.697'W, 45°17.322'N). Final BWs were obtained on December 19.

In 2017, 156 non-lactating cows were allocated to treatment pastures on October 24 and 25 and 24 collars were placed on a subset of 2-yr-old cows allocated as described for 2016. Cattle weights were not obtained when cattle were received due to a 48-h fast plus trucking that cattle were subjected to from October 23 to 24. Rather, beginning BWs were determined from September 13 BW at calf weaning. Cattle BWs were obtained November 20 with collars being left on cows until shipping to Carmen on December 12. Final BWs were obtained on December 14.

Grazing Behavior Observations and Data Processing

Estimates of grazing time, resting time, and walking time were estimated every 5 s using the 3-axis accelerometer. Data were compiled using Python coding (<https://www.python.org/>). Observed daily activity for each cow was obtained by one or two horseback observers over multiple time periods over 3 d. Observational sampling occurred during peak grazing periods in early morning and late afternoon and during midday when cows rest. Reliable walking data were collected as cows were trailed to and from corrals.

Equations used to evaluate accelerometer *g* values included the *x*, *y*, and *z* axes and the equations $x + y + z$, $x \times z$, $x \times y + z$, average and maximum for movement intensity $\{\text{SQRT of } (x^2 + y^2 + z^2)\}$, and the average and maximum for signal amplitude $\{\text{ABS}(x) + \text{ABS}(y) + \text{ABS}(z)\}$. These equations were evaluated for each cow using both error scores and plotted probability plots obtained from quadratic discriminant analysis (SAS, v. 9.4; SAS Institute, Inc., Cary, NC). The equation chosen was summarized by day for each 2-h time period beginning at 2400 hours.

The GPS loggers recorded locations at 2-min intervals and daily travel distance (DTD) was along

the travel path. All waypoints exceeding 84 m/min travel time and all waypoints exceeding 300 m estimated horizontal positional error were eliminated. Also, points with altitudes <1,500 m or >2,500 m from the data loggers were eliminated. In ArcMap (v. 10.2.2, Esri, Inc., Redlands, CA), GPS positions appearing outside of the mapped fence line were deleted. Data were then compared from day to day, and those points sharply diverging from the general path were deleted.

Statistical Analyses

Daily grazing time, resting time, and walking time were analyzed with a mixed effects model for repeated measures (v. 9.4, SAS Institute, Inc.) with the fixed effects of pasture treatment, year, RFI group, and the interactions between RFI group \times year and pasture treatment \times year. Cow within RFI group \times pasture treatment was included as a random repeated subject. DTD was analyzed by year with the fixed effects of pasture treatment, date, RFI group and the interactions between RFI group \times pasture treatment and pasture treatment \times date. The same repeated random effect was used for this model. Cow BW was analyzed with the fixed effects of pasture treatment, year, cow age, and the interactions between pasture treatment \times year, pasture treatment \times cow age, cow age \times year, and pasture treatment \times cow age \times year. Cow within pasture treatment was the repeated random effect used in this analysis. The denominator degrees of freedom for daily activity and DTD F-statistics were approximated using the Kenward–Roger's method. For cow production data, the Satterthwaite method was used. For all these models, a simplified compound symmetry covariance structure was used to model the relationships between repeated observations. Least squares treatment means for all statistical models were separated using the pairwise contrasts (PDIF, v. 9.4, SAS Institute, Inc.).

RESULTS AND DISCUSSION

Climatic Data

This trial spanned two very different years climatically. The 2016 year received record moisture in October (119 mm). When cattle were trailed to the shipping corrals at the conclusion of the trial on December 12, snow was 48-cm deep and the temperatures were below -14°C . Conversely, 2017 had milder weather with minimal snow and temperatures did not decline below -8°C . One complication of the wet 2016 year was that cattle in the 1,381-ha

pasture were able to access the entire pasture due to pockets of standing water. Consequently, DTD for this large pasture exceeded that of any other pasture treatment (Table 1).

Animal Performance

Figure 1 presents the BW for cows with their different pasture treatments. Cattle that stayed in the same pasture without any added protein supplement lost more BW ($P < 0.0001$) than any of the other treatments. Of particular interest in Figure 1 is the performance exhibited by cows in the RCON pasture treatment. With pasture rotations, cattle have the opportunity to more readily access better quality forage and to express dietary selection, not unlike being provided with an intermediate level of supplementation.

Grazing Behavior

Table 1 presents the DTD for both pasture treatments and RFI classification. The greater travel distance observed for CTRT in 2016 was explained earlier. Cattle grazing the smaller rotated pastures in 2016 had less ($P < 0.05$) DTD than did cattle grazing the larger pastures. In 2017, cattle in the RTRT traveled further ($P < 0.05$) than did cattle in the RCON pasture. No differences in DTD were apparent ($P > 0.05$) for LRFI vs. HRFI in either year. Unlike some other studies (Schauer et al., 2005), supplemented cattle in this trial did not reduce grazing time ($P = 0.71$; Table 1), though they did reduce 2017 grazing time 29% of the time on the day weekly protein supplement was provided and 14% of the time the day after being supplemented (Figure 2). There were no ($P > 0.10$) differences for grazing time on the day of supplementation or the day following in 2016. Possibly, cattle did not reduce overall daily grazing time in our study due to providing supplement at midday when cattle are typically idle. Schauer et al. (2005) provided supplement at 0800 hours, which is typically during one of the peak grazing periods of the day. Any adaptations cattle in this study made for daily activity was made by reducing or increasing resting time with an accompanying change in the amount time spent walking (Table 1). Preliminary evidence offered here (Table 1) suggests that cattle on continuously grazed late-season rangeland with an opportunity for accessing an improved diet (CTRT) altered their grazing behavior in 2017 when compared with their unsupplemented counterparts (CCON), spending less time walking ($P < 0.05$), and more time resting ($P < 0.05$). Similarly, cattle with lesser maintenance requirements (as defined by LRFI classification)

Table 1. Grazing behavior for LRFI and HRFI 2-yr-old cows on late-season rangeland

Item	Pasture treatment ¹				RFI classification ²	
	CCON	CTRT	RCON	RTRT	LRFI	HRFI
DTD ³ , km/d						
2016	11.6 ± 0.23 ^b	13.5 ± 0.23 ^a	9.3 ± 0.25 ^c	9.6 ± 0.25 ^c	10.8 ± 0.17 ^a	11.2 ± 0.17 ^a
2017	8.0 ± 0.26 ^{ab}	8.3 ± 0.26 ^{ab}	7.8 ± 0.26 ^b	8.7 ± 0.30 ^a	8.4 ± 0.18 ^a	8.1 ± 0.20 ^a
Grazing, h/d						
2016	10.5 ± 0.27 ^a	10.7 ± 0.27 ^a	10.6 ± 0.26 ^a	10.6 ± 0.28 ^a	10.6 ± 0.19 ^a	10.6 ± 0.19 ^a
2017	10.5 ± 0.25 ^a	10.4 ± 0.28 ^a	10.9 ± 0.27 ^a	10.4 ± 0.27 ^a	10.5 ± 0.20 ^a	10.6 ± 0.18 ^a
Resting, h/d						
2016	10.5 ± 0.32 ^a	10.6 ± 0.32 ^a	10.7 ± 0.32 ^a	10.8 ± 0.34 ^a	10.5 ± 0.23 ^a	10.8 ± 0.24 ^a
2017	10.3 ± 0.30 ^b	11.3 ± 0.34 ^a	10.7 ± 0.33 ^{ab}	10.6 ± 0.33 ^{ab}	11.0 ± 0.24 ^a	10.4 ± 0.22 ^a
Walking, h/d						
2016	3.0 ± 0.30 ^a	2.7 ± 0.30 ^a	2.7 ± 0.29 ^a	2.6 ± 0.32 ^a	2.9 ± 0.21 ^a	2.6 ± 0.22 ^a
2017	3.2 ± 0.29 ^a	2.3 ± 0.32 ^b	2.4 ± 0.32 ^{ab}	2.9 ± 0.30 ^{ab}	2.4 ± 0.23 ^a	3.0 ± 0.20 ^a

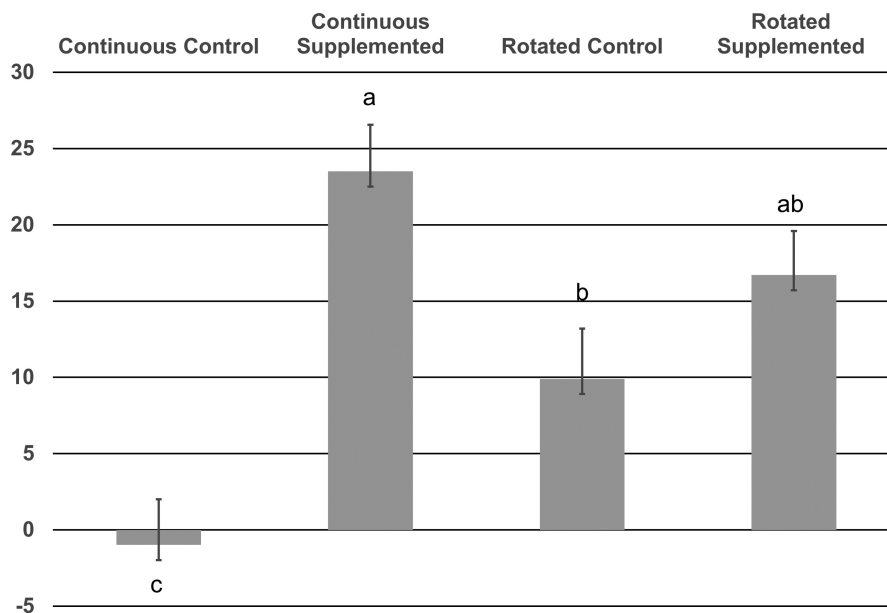
^{abc}Means within category and row differ ($P < 0.05$). The main effect P value for pasture treatment × year was 0.512 for resting whereas the mean comparison between CCON and CTRT in 2017 had a P value = 0.0382. The main effect P value for pasture treatment × year was 0.573 for walking whereas the mean comparison between CCON and CTRT in 2017 had a P value = 0.0358. The main effect P value for RFI classification × year was 0.0505 for resting with the mean comparison between LRFI and HRFI in 2017 having a P value = 0.0796. The main effect P value for RFI classification × year was 0.0356 for walking with the mean comparison between LRFI and HRFI in 2017 having a P value = 0.0693.

¹CCON = Continuously grazed pasture, no protein supplement ($n = 3$ LRFI, 3 HRFI for each year); CTRT = continuously grazed pasture, 3.17 kg of 28% protein supplement per cow/wk fed once a week ($n = 3$ LRFI, 3 HRFI for each yr for DTD, 1 less LRFI cow for resting, grazing, and walking for 2017); RCON = rotational grazing, no protein supplement ($n = 2$ LRFI, 3 HRFI for 2016, 3 LRFI and 3 HRFI for 2017); RTRT = rotational grazing, 3.17 kg of 28% protein supplement per cow/wk fed once a week ($n = 3$ LRFI, 2 HRFI for 2016, 3 LRFI and 2 HRFI for 2017 DTD).

²LRFI = low-residual feed intake ($n = 11$ for 2016 DTD, 12 for 2017 DTD, 12 for 2016 resting, grazing, and walking, 10 for 2017 resting, grazing, and walking); HRFI = high-residual-feed intake ($n = 11$ for 2016 DTD and resting, grazing, and walking, $n = 11$ for 2017 DTD and 12 for 2017 resting, grazing and walking).

³DTD = Daily travel distance.

Weight Change Beginning to End, kg



a, b Means with different subscripts differ, $P < 0.0001$.

Figure 1. Cow BW change while grazing late-season rangeland for 54 d in 2016 and 45 d in 2017. Supplemented cows received 3.17 kg of 28% dried distillers grain protein cube per cow/wk fed once a week. There were 75 cows in the continuously grazed control, 71 cows in the continuously grazed supplemented, and 73 cows each in the rotationally grazed control and rotationally grazed supplemented pastures over the 2-yr study.

demonstrated a tendency ($P < 0.10$) to walk less and rest more than HRFI cows in 2017. With greater sample sizes for observed grazing behavior,

adaptations in cattle grazing behavior on late-season rangeland may become more apparent, but the trends presented in Table 1 demonstrated important

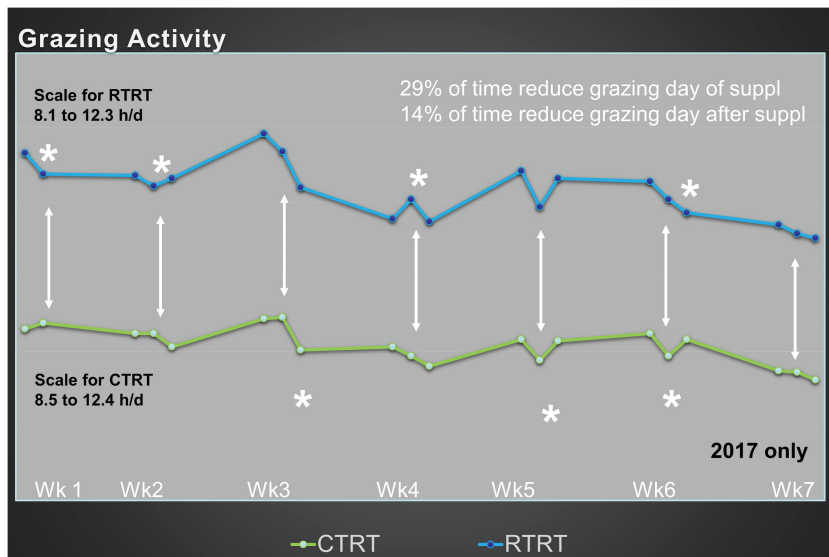


Figure 2. Cow grazing activity before and after supplementation. Each data point on the continuously-grazed (CTRTR, lower line) and rotationally-grazed (RTRTR, upper line) pastures represent the day before protein supplementation, the day of supplementation, and the day following supplementation. Arrows indicate the day supplement was delivered. Week 1 had no grazing activity recorded the day preceding protein supplementation. Asterisks indicate when grazing activity was different ($P < 0.05$) or tended to be different ($P < 0.10$).

concepts to consider. Our experimental hypothesis was validated by this research as cattle with greater nutritional demands expressed this by reducing resting time and increasing walking time, perhaps an indication of searching for a higher quality diet.

ACKNOWLEDGMENTS

This work was supported by the United States Department of Agriculture, National Institute of Food and Agriculture, Hatch Project 1010550. We acknowledge the support of United States Department of Agriculture, Agricultural Research Service employees N. Strong, R. Laird, B. Leonard, J. Hensley, and M. Williams in helping execute the project.

Conflict of interest statement. None declared.

LITERATURE CITED

- Hall, J. B., J. B. Glaze, Jr, W. K. Smith, and M. C. Roberts. 2015. Relationship among feed efficiency traits and reproduction in heifers. *Proc. West. Sec. Amer. Soc. Anim. Sci.* 66:272–276.
- Leng, R. A. 1990. Factors affecting the utilization of “poor-quality” forages by ruminants particularly under tropical conditions. *Nutr. Res. Rev.* 3:277–303. doi:10.1079/NRR19900016
- Schauer, C. S., D. W. Bohnert, D. C. Ganskopp, C. J. Richards, and S. J. Falck. 2005. Influence of protein supplementation frequency on cows consuming low-quality forage: performance, grazing behavior, and variation in supplement intake. *J. Anim. Sci.* 83:1715–1725. doi:10.2527/2005.8371715x
- Sprinkle, J. E., J. B. Taylor, P. E. Clark, M. C. Roberts-Lew, and J. B. Hall. 2016. Grazing behavior and production characteristics among cows differing in residual feed intake while grazing late season Idaho rangeland. *Proc. West. Sec. Amer. Soc. Anim. Sci.* 67:1–5.