The influence of age and environmental conditions on supplement intake and behavior of winter grazing beef cattle on mixed-grass rangelands

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INTRODUCTION

Beef cattle production on Montana farms accounted for $1.78 billion of gross income and 42% of total agricultural sales in 2012 (USDA-NASS, 2016). Economic efficiency of cattle production is threatened by high feed and input costs (Meyer and Gunn, 2015). To improve profitability and transition to reduced reliance on transported harvested feeds, many cow-calf producers have adopted management strategies involving dormant season grazing extending into the winter months (Adams et al., 1996).

Winter grazing typically exposes cattle to periods of severe cold which increases energy expenditure to maintain homeothermy (Webster, 1970, 1971). In addition, at cold temperatures, wind induces a higher metabolic rate and heat production (Webster, 1970; Christopherson et al., 1979). Thus, winter conditions can have considerable economic impact on the energetic efficiency of cattle production on rangelands (Webster, 1970).

In order to meet the nutritional needs and maintain a desired level of productivity on nutrient-deficient rangelands during winter months, supplemental protein is often provided to increase intake and performance (Lusby et al., 1967; Bowman et al., 1995; Bodine et al., 2001). Supplementation strategies assume that all animals consume a targeted quantity of supplement (Bowman and Sowell, 1997). However, this ignores variation of supplement intake by individual cows, often influenced by social dominance associated with age class within the production (Webster, 1970; Christopherson et al., 1979). Thus, winter conditions can have considerable economic impact on the energetic efficiency of cattle production on rangelands (Webster, 1970).

Effectiveness of supplementation programs on grazing cattle performance have been inconsistent (DelCurto et al., 1990). This inconsistency may be due to variation in supplement intake by individual cows, often influenced by social dominance associated with age class within the
herd (Wagnon, 1965; Friend and Polan, 1974). Potential changes in energetic requirements to maintain homeothermy could alter supplement intake during winter months. Therefore, the goal of this research is to examine the effects of cow age and environmental conditions on individual supplement intake and behavior of cattle grazing winter rangelands in Montana. We hypothesize that both cow age and winter environmental conditions affect daily supplement intake, as well as, the variation in supplement intake.

MATERIALS AND METHODS

The use of animals in this study was approved by the Institutional Animal Care and Use Committee of Montana State University.

This study was conducted at the Thackeray Ranch (48°21′N 109°30′W), part of the Montana Agricultural Experiment Station located 21 km south of Havre, MT. Climate is characterized as semi-arid steppe with an average annual precipitation of 410 mm. Vegetation is dominated by Kentucky bluegrass (Poa pratensis L.), bluebunch wheatgrass (Pseudoroegneria spicata [Pursh] A. Love), and rough fescue (Festuca scabrella Torr.).

A commercial herd of bred cows (Angus, Angus × Simmental) ranging in age from 1- to 12-yr-old grazed on a 329 ha rangeland pasture (~1.2 ha AUM−1) during 2 yr (272 cows in the first year, and 302 cows in the second year). The winter grazing season occurred from 1 December 2016 to 12 January 2017, and 1 November 2017 to 31 December 2017. All cattle had free-choice access to a 30% CP self-fed canola meal-based (35% as-fed basis) pelleted supplement with 25% salt to limit intake (Table 1). The target daily intake was 0.91 kg/cow. Each individual animal was equipped with an electronic ID tag (Allflex USA, Inc., Dallas-Ft. Worth, TX) attached to the exterior of the left ear for the measurement of individual supplement intake, number of visits, visit length, and intake rate using a SmartFeed Pro self-feeder system (C-Lock Inc., Rapid City, SD) which provided a total of eight feeding stations.

Cattle were assigned to one of six age classifications (1-yr-old, 2- and 3-yr-olds, 4- and 5-yr-olds, 6- and 7-yr-olds, 8- and 9-yr-olds, and ≥10-yr-old) to evaluate the effects of age class on average daily individual supplement intake, number of visits, visit length, intake rate, and CV of supplement intake. Each cow was considered an experimental unit. Supplement intake variables were analyzed using ANOVA with a mixed model including age class, year, and the interaction of age class and year as fixed effects, and individual cow × age class as the random effect (R Core Team, 2017). Least square means were separated using the LSD method when \( P < 0.05 \).

An Onset (Bourne, MA) HOBO U30-NRC Weather Station was placed near the supplement feeders and programmed to collect air temperature, relative humidity, and wind speed and direction data every 15 min for the entirety of the grazing period. Models were developed representing hypotheses examining the influence of environmental conditions and age class on daily supplement intake. The variables considered as candidates for modeling included average daily temperature, average daily wind speed, age class, and year. Cow was used as a random effect. Akaike’s information criterion adjusted for small sample sizes (AICc) was then used to evaluate support for competing models (Burnham and Anderson, 2002). All data were analyzed using generalized linear mixed models in R (R Core Team, 2017).

RESULTS

The effects of age class on intake-related variables displayed an age class × year interaction \( (P < 0.05) \); therefore, data is displayed for each year independently (Table 2). Daily supplement intake, feeding time, and intake rate decreased linearly \( (P < 0.05) \) as age class increased in the first year, while daily intake CV, and feeder visits per day had a quadratic \( (P < 0.01) \) response to age class. In year 2, there was no effect \( (P > 0.09) \) of age class on daily intake or daily intake CV. Visits per day, and intake rate decreased \( (P < 0.01) \) linearly as age class increased, while feeding time increased \( (P < 0.01) \) linearly with increasing age class.

### Table 1. Supplement composition for cattle winter grazing rangeland in 2016 and 2017 at the Thackeray Ranch, Havre, MT (as-fed basis)

| Component     | 2016 Composition (as-fed basis) | 2017 Composition (as-fed basis) |
|---------------|---------------------------------|---------------------------------|
| CP            | 30.00%                          | 30.00%                          |
| Crude fat     | 1.00%                           | 1.00%                           |
| Crude fiber   | 8.00%                           | 8.00%                           |
| Ca            | 2.00%                           | 2.00%                           |
| P             | 0.00%                           | 0.00%                           |
| Salt          | 25.00%                          | 25.00%                          |
| K             | 0.75%                           | 0.75%                           |
| Se            | 1.5 ppm                         | 1.5 ppm                         |
| Vitamin A     | 9,072 IU/kg                     | 9,072 IU/kg                     |
| Vitamin D     | 907 IU/kg                       | 907 IU/kg                       |
| Vitamin E     | 9 IU/kg                         | 9 IU/kg                         |

*9.9% nonprotein N.*
When evaluating the effects of environmental conditions and age class on supplement intake, we found a single top model containing year, temperature, and a temperature × age class interaction received 100% of the $\text{AIC}_c$ total weight (Table 3). Our top model reveals that

### Table 2. Average daily supplement intake and behavior by age class for cattle winter grazing rangeland in 2016 and 2017 at the Thackeray Ranch, Havre, MT

| Age class | 1  | 2  | 3  | 4  | 5  | 6  | SEM | Linear | Quadratic |
|-----------|----|----|----|----|----|----|-----|--------|-----------|
| **Year 1** |    |    |    |    |    |    |     |        |           |
| Daily intake, kg | 1.9 | 1.9 | 1.5 | 1.3 | 1.2 | 1.4 | 0.1 | <0.01  | 0.11      |
| Daily intake CV, % | 62.2 | 65.8 | 77.3 | 89.3 | 89.7 | 78.7 | 1.1 | <0.01  | <0.01     |
| Visits per day | 7.0 | 5.5 | 3.9 | 3.4 | 3.0 | 3.7 | 0.3 | <0.01  | <0.01     |
| Feeding time, min/d | 6.6 | 6.1 | 5.3 | 5.2 | 4.9 | 5.6 | 0.4 | 0.05   | 0.07      |
| Intake rate, g/min | 343.5 | 371.2 | 332.6 | 310.0 | 322.3 | 312.2 | 12.8 | 0.02   | 0.92      |
| **Year 2** |    |    |    |    |    |    |     |        |           |
| Daily intake, kg | 1.5 | 2.1 | 1.8 | 1.7 | 1.8 | 2.0 | 0.1 | 0.09   | 0.87      |
| Daily intake CV, % | 70.8 | 61.4 | 70.6 | 71.0 | 69.7 | 71.6 | 1.0 | 0.19   | 0.52      |
| Visits per day | 7.1 | 7.7 | 6.1 | 5.7 | 6.2 | 5.9 | 0.3 | <0.01  | 0.31      |
| Feeding time, min/d | 5.3 | 7.3 | 6.8 | 6.7 | 7.8 | 8.6 | 0.4 | <0.01  | 0.94      |
| Intake rate, g/min | 344.6 | 340.6 | 340.4 | 321.0 | 311.7 | 296.0 | 10.4 | <0.01  | 0.37      |

*P values for linear and quadratic effects of cow age class.

### Table 3. Model selection for models evaluating the effects of environmental conditions and age class on supplement intake for cattle winter grazing rangeland in 2016 and 2017 at the Thackeray Ranch, Havre, MT

| Model                                      | $K$ | $\text{AIC}_c$   | $\Delta\text{AIC}_c$ | $W_i$ |
|--------------------------------------------|-----|-----------------|-----------------------|-------|
| Year + temp × age class                    | 15  | 28,404.75       | 0.00                  | 1.00  |
| Year + temp × age class + wind speed       | 16  | 28,417.86       | 13.12                 | 0.00  |
| Year + temp × age class + wind speed × age class | 21  | 28,452.34       | 47.59                 | 0.00  |
| Constant (null)                            | 3   | 28,646.06       | 241.31                | 0.00  |

*Cow is used as a random variable in all models. Only models with a Akaike weight ($W_i$) > than the null model are presented.

$K$ = number of parameters.

$W_i$ = Akaike weight.

Figure 1. Model output and confidence intervals (85%) evaluating the interaction of temperature × age class on supplement intake of cattle during the winter grazing period for 2016 and 2017 at the Thackeray Ranch, Havre, MT.
Table 4. Mean, minimum, and maximum temperature (°C) during winter grazing period for 2016 and 2017 at the Thackeray Ranch, Havre, MT

| Year | Mean | Min | Max |
|------|------|-----|-----|
| Year 1 | −9.6 | −22.7 | 3.8 |
| Year 2 | −2.0 | −24.3 | 14.9 |

temperature interacts with age class, where young animals increase supplement intake as temperature decreases, while older animals decrease supplement intake as temperature decreases (Figure 1). Year represented an additive effect where cows had higher average daily supplement intakes in year 2 than in year 1.

DISCUSSION

The few studies that have quantified supplement intake in mixed-age herds have shown older cows spend more time at the feeder and consume more supplement than younger cows (Earley et al., 1999; Sowell et al., 2003). However, our results contradict this conventional idea with higher daily supplement intake by younger cows in year 1, and increased visits per day, and intake rate ($P < 0.05$) by younger cows in both year. Our research suggests that temperature alone can interact with cow age in altering supplement intake behavior. Our top model supports this idea, as mean temperatures in year 1 were substantially lower than year 2 (−9.6 vs. −2.0 °C; Table 4), potentially resulting in greater energetic needs for young cows to maintain homeothermy.

Specific factors such as cow age, environmental conditions, and supplement form need to be evaluated to determine the influence they play on supplement intake behavior. By providing a supplement delivery system that optimizes uniformity of consumption and minimizes economic inputs, we can effectively improve the efficiency of beef cattle production systems.

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