Effects of mineral-supplement delivery system on frequency, duration, and timing of supplement use by beef cows grazing topographically rugged, native rangeland in the Kansas Flint Hills¹,²

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ABSTRACT: The effects of mineral-supplement delivery system on patterns of supplement use by grazing beef cows were measured in 2 studies. Study 1 was conducted on 4 pastures grazed by pregnant, mature beef cows (BW = 562 ± 38 kg) from February to May. Study 2 was conducted on 4 pastures grazed by lactating beef cows (BW = 579 ± 54 kg) and their calves from May to September. Treatments were mineral delivered in salt-based, granular form (salty) or mineral provided in a low-protein, cooked, molasses-based block (sweet); both were fed ad libitum. The salty supplement was supplied to cattle via a covered mineral feeder; the sweet supplement was supplied via an open-topped barrel. Both salty and sweet supplements were deployed in each pasture. No additional salt was supplied to cattle. Forage use in the vicinity of each supplement-deployment site and the frequency and duration of herd visits to each supplement-deployment site were measured during four 14-d periods during study 1 and seven 14-d periods during study 2. Supplements were moved to new locations within pastures at the beginning of each period. Consumption of the sweet supplement was greater than salty during each data-collection period in study 1; however, relative differences in consumption diminished over time (treatment × time, P = 0.03). In study 2, sweet consumption was greater than salty in periods 1, 6, and 7 but was not different from salty during periods 2, 3, 4, and 5 (treatment × time, P < 0.01). Increased consumption of the sweet supplement in study 1 translated to greater frequency of herd visits to supplement-deployment sites compared with the salty sites (2.82 vs. 2.47 herd visits/d; P = 0.02) and longer herd visits to supplement-deployment sites compared with the salty sites (125.7 vs. 54.9 min/herd visit; P < 0.01). The frequency of herd visits to mineral feeding sites in study 2 was similar (P > 0.10) between treatments for periods 1 through 6; however, herds visited the sweet sites more often than salty during period 7 (P < 0.01). Herd visits to the sweet sites were longer than those to the salty sites in study 2 (83.8 vs. 51.4 min/herd visit; P < 0.01). Forage disappearance within 100 m of supplement-deployment sites was not influenced (P ≥ 0.54) by treatment in either study. Results were interpreted to suggest that the sweet supplement influenced the location of grazing cattle more strongly than the salty supplement and may be more effective for luring cattle into specific areas of pasture during the winter, spring, and early fall but not during summer.

Key words: beef cattle, grazing behavior, mineral supplement, native range

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doi:10.2527/jas.2010-3808

INTRODUCTION

Uneven grazing distribution can result in localized over- and undergrazing on native rangelands. Grazing animals tend to congregate and graze heavily in areas near water, near shade, and on level terrain, while abundant forage remains on less-preferred range sites (Smith et al., 1992; Bailey, 2004). Concentrated grazing activity results in soil compaction and undesirable shifts in plant species composition on native rangelands (Greenwood and McKenzie, 2001). These negative ef-
fects can be minimized by preventing localized overgrazing (Pieper, 1984; Jones, 2000; Launchbaugh and Howery, 2005).

Water development, cross-fencing, and herding can improve the overall uniformity of forage use in individual pastures (Skovlin, 1957; Cook, 1966; Knuffman and Krueger, 1984; Bailey and Rittenhouse, 1989; Bailey and Welling, 1999; Butler, 2000). These interventions to protect sensitive range sites by modifying grazing activities of livestock tend to be costly or labor intensive. Strategic placement of supplemental trace mineral or salt can be an effective, low-cost way to entice cattle into underused and away from overused areas of range and pasture (Porath et al., 2002; Bailey and Welling, 2007). Cattle spend up to 40% of their time within 600 m of the location of self-fed supplements (Bailey et al., 2001); moreover, cattle spent more time within 600 m of supplements with greater relative palatability compared with those with moderate palatability (Bailey and Welling, 2002). Little research has directly compared the effects of mineral supplements with differing flavor characteristics on behavior of grazing cattle. Therefore, our objective was to measure intake, frequency of use, and duration of use of mineral supplements with divergent flavor characteristics by cattle grazing native-tallgrass range during different seasons of the year and to estimate the change in forage availability around supplement-deployment sites.

MATERIALS AND METHODS

The Kansas State University Institutional Animal Care and Use Committee approved all animal handling and animal care practices used in this research.

Two studies were conducted on pastures managed by the Kansas State University Commercial Cow-Calf Unit. Study 1 was conducted on 4 adjacent native tallgrass pastures located in Riley County, Kansas (average size = 123 ± 5 ha; 39.2310° N, 96.6698° W) from February to May. Each pasture contained a single centrally located water source. Topographical relief in this study area varied from 330 to 410 m; approximately 85% of the land area fell within the range of 4 to 14% slope. Mature, pregnant, nonlactating beef cows (n = 240; average initial BW = 562 ± 38 kg) were stratified by BW and parity and assigned randomly to pastures (n = 60 cows/pasture). Study 2 was conducted on 4 adjacent native tallgrass pastures located in Geary County, Kansas (average size = 89 ± 31 ha; 38.9987° N, 96.5495° W) from June to September. Each pasture contained a single centrally located water source. Topographical relief varied from 320 to 445 m; approximately 90% of the land area fell within the range of 4 to 14% slope. Mature, lactating beef cows (n = 188; average initial BW = 579 ± 54 kg) with suckling calves were stratified by BW and parity and assigned randomly to pastures (n = 30 to 70 cow-calf pairs/pasture). Cows used to conduct study 2 were chosen randomly from among those used to conduct study 1.

Major graminoid species in pastures, in order of dominance, were big bluestem (Andropogon gerardii Vitman), indiangrass [Sorghastrum nutans (L.) Nash], little bluestem [Schizachyrium scoparium (Michx.) Nash], sideoats grama [Bouteloua curtipendula (Michx.) Torr.], and switchgrass (Panicum virgatum L.; Towne and Owensby, 1984). Pastures were stocked at 3.24 ha/cow during studies 1 and 2.

Treatments were mineral delivered in dry, salt-based, granular form (salty) or mineral delivered in a low-protein, cooked, molasses-based block (sweet; Table 1); both were fed to cattle ad libitum. Supplements were formulated to contain similar amounts and availabilities of macro- and trace minerals; however, the salty supplement was based on NaCl (19%) and the sweet supplement contained no NaCl. The physical forms of our supplements were dissimilar also; sweet was formulated as a deliquescent semi-solid, whereas salty was a simple mixture of dry, granular minerals without any type of binding agent. The salty supplement was supplied to cattle via a covered mineral feeder (0.75 m diameter); sweet was supplied via an open-topped barrel provided by the manufacturer (57 kg; 0.75 m diameter). Both salty and sweet supplements were deployed in each pasture, allowing animals within individual pastures the opportunity to display a preference for 1 supplement type over the other.

No additional NaCl was supplied to cattle in our study even though manufacturers of low-protein, molasses-based mineral supplements commonly recommend that such products be colocated on pasture with salt. The major objective of our study was to make a

<table>
<thead>
<tr>
<th>Item</th>
<th>Salt-based granular</th>
<th>Molasses-based block</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP, %</td>
<td>—</td>
<td>4</td>
</tr>
<tr>
<td>Crude fat, %</td>
<td>—</td>
<td>3</td>
</tr>
<tr>
<td>Ca, %</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>P, %</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>NaCl, %</td>
<td>19</td>
<td>—</td>
</tr>
<tr>
<td>Cu, mg/kg</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Co, mg/kg</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>I, mg/kg</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Mn, mg/kg</td>
<td>4,000</td>
<td>4,000</td>
</tr>
<tr>
<td>Se, mg/kg</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Zn, mg/kg</td>
<td>4,000</td>
<td>4,000</td>
</tr>
</tbody>
</table>

1Supplied by manufacturers.
2Custom blend; Farmer’s Cooperative Inc., Onaga, KS.
365% molasses solids; New Generation Feeds, Belle Fourche, SD.
direct comparison of the relative attractiveness of sweet vs. salty bases for mineral supplements, independent of the influence of white salt.

The frequency and duration of herd visits to supplement-deployment sites and the change in forage availability in the area of supplement-deployment sites were measured during 4 data-collection periods during study 1 and 7 data-collection periods during study 2. All data-collection periods were 14 d in length. Supplement-deployment sites were selected to fall within the range of 4 to 14% slope. Within a pasture and a data collection period, supplement-deployment sites were grouped into sets of 2 based on similar forage species composition, shade availability, aspect, slope, and horizontal distance from water. Each site within a set was assigned randomly to either the salty or sweet supplement. Within pasture, matched supplement-deployment sites were a minimum of 250 m from one another.

One grazing-exclusion cage (1.5 m diameter) was set up at each supplement-deployment site to serve as an index of ungrazed forage availability and quality. Forage samples were collected from inside grazing-exclusion cages at the beginning and end of each data-collection period by clipping forage 1 cm above the ground from within a randomly placed sampling frame (0.25 m²).

Forage samples were weighed and dried in a forced-air oven (96 h; 50°C) to estimate DM forage availability. Average forage availability during each month of studies 1 and 2 was reported (Table 2). Forage samples were ground to pass a 1-mm screen (No. 4 Wiley mill, Thomas Scientific, Swedesboro, NJ) and composited on an equal-weight basis within month. Composite samples were analyzed for DM (12 h; 105°C), OM (8 h; 450°C), and Kjeldahl N. These samples were also analyzed for NDF and ADF using procedures described by Van Soest et al. (1991). Average forage quality during each month of studies 1 and 2 was reported (Table 2).

Supplements were moved to new locations on d 1 of each data-collection period. A circular area (radius = 100 m) around each supplement site was assessed for standing forage biomass using a visual obstruction method (Robel et al., 1970) on d 1 and 14 of each data-collection period. Standing forage biomass estimates at each supplement site were conducted along 4 transects 100 m in length; 25 estimates of biomass were collected per transect. The difference between initial and final estimates of standing forage biomass during each data-collection period was considered to represent change in forage availability.

The frequency and duration of herd visits to each supplement-deployment site were recorded using motion-sensitive digital cameras. Cameras (STC-TGL3M, Wildview; 1 per supplement-deployment site) were mounted 2 m above ground and trained on supplement feeders from a distance of 9 m. The field of view of the cameras was approximately 30° at that distance. Digital photographs were collected at 5-min intervals from the time the first animal in the herd approached the supplement until the last animal departed. Visits to each supplement-deployment site were recorded as daytime (0600 to 1800 h) or nighttime visits (1800 to 0600 h). The duration of herd visits to supplement sites was defined as the interval of time between when the first and last pictures were taken. A herd visit was considered terminated when the interval between pictures was >60 min. The frequency of herd visits to supplement sites was considered to be the total number of herd visits per data-collection period divided by the number of days in each data-collection period (i.e., 14).

Mineral consumption was visually assessed each day during data-collection periods to ensure ad libitum availability. Total consumption of the salty and sweet supplements was determined gravimetrically on d 1 and 14 of each data-collection period. Disappearance of supplement was considered equivalent to consumption.

Table 2. Average standing forage biomass in native tallgrass-prairie pastures (±SD) and chemical composition of native tallgrass-prairie forage grazed by beef cows during study 1 and beef cows and calves during study 2

<table>
<thead>
<tr>
<th>Item</th>
<th>Study 1</th>
<th>Study 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>March²</td>
<td>April²</td>
</tr>
<tr>
<td>Forage availability, kg of DM/ha</td>
<td>2,763 ± 443</td>
<td>2,357 ± 379</td>
</tr>
<tr>
<td>DM, %</td>
<td>94.8</td>
<td>88.0</td>
</tr>
<tr>
<td>OM, %</td>
<td>88.9</td>
<td>86.8</td>
</tr>
<tr>
<td>CP, % of DM</td>
<td>5.3</td>
<td>5.4</td>
</tr>
<tr>
<td>NDF, % of DM</td>
<td>76.0</td>
<td>72.5</td>
</tr>
<tr>
<td>ADF, % of DM</td>
<td>44.6</td>
<td>43.2</td>
</tr>
</tbody>
</table>

¹Estimates were derived from hand-clipped samples collected from within grazing-exclusion cages.
²Harvest month.
when $P > 0.05$ and $\leq 0.10$. When interaction effects were significant, main effect means were not reported.

**RESULTS AND DISCUSSION**

Standing forage biomass in study 1 ranged from 2,763 ± 443.4 kg/ha during March to 2,242 ± 583.9 kg/ha during May. Standing forage biomass in study 2 ranged from 3,786 ± 824.1 kg/ha in August to 2,631 ± 534.4 kg/ha in June (Table 2). Based on these figures, we concluded that forage availability did not limit DMI of cows at the stocking rates used in our study.

Consumption of the sweet supplement was greater than salty during each data-collection period in study 1 (Figure 1); however, the magnitude of the difference was affected by period (treatment × period, $P = 0.03$). Consumption of both supplement types appeared to decline over time as the forage transitioned from winter dormancy to active spring growth. Average consumptions of sweet and salty supplements during study 1 were 0.19 and 0.06 kg·cow$^{-1}$·d$^{-1}$, respectively. In study 2, intake of the sweet supplement was greater than salty during data-collection periods ending in early June, mid-September, and late September; however, voluntary intakes of sweet and salty supplements were not different during data-collection periods ending in late June, July, and August (treatment × period, $P < 0.01$; Figure 2). Bailey and Welling (2007) concluded that beef cows consumed more Cu, Zn, and P from dry, granular mineral than from low-moisture molasses blocks; however, cows were not given access to both supplements at the same time in that study.

Average consumption of the sweet and salty supplements during study 2 was 0.20 and 0.13 kg·cow$^{-1}$·d$^{-1}$, respectively. Average consumption of the salty supplement in study 2 was roughly double that in study 1 (0.13 vs. 0.06 kg·cow$^{-1}$·d$^{-1}$, respectively). In contrast, average intake of the sweet supplement in study 2 was similar to that observed during study 1 (0.20 vs. 0.19 kg·cow$^{-1}$·d$^{-1}$, respectively). Average intakes of the sweet and salty supplements must be interpreted in light of possible variations in intake within and among individual animals. Bowman and Sowell (1997) indicated that across a variety of environments and supplement formulations, intakes of supplements in block form (e.g., sweet) were more variable over time and from animal-to-animal than intakes of supplements in dry form (e.g., salty). Treatment effects on animal performance in our study were impossible to parse because animals had simultaneous access to both sweet and salty supplements. Independent of average intake rates, performance of individual beef cows may have been influenced by the physical form of our supplements if supplement consumption was erratic from day-to-day or animal-to-animal as a result.

Intake of the sweet supplement in our study was similar to that reported by Bailey and Welling (1999) and Bailey et al. (2008); however, it should be noted that percentage CP of the product used in those studies was roughly 6.5 times that of the product used in our study. Bailey and Welling (2007) compared intakes of a conventional, dry mineral supplement with intakes of a low-protein, molasses-based mineral supplement (i.e., 3% CP) by beef cows. In that study, cows did

![Figure 1](image.png)

**Figure 1.** Effect of mineral-supplement delivery system and advancing season on intake of mineral supplements by beef cows during study 1 (treatment × period interaction; $P = 0.03$). Error bars represent the SE of the least squares means.
not have simultaneous access to both products; moreover, a molasses-based protein supplement (27% CP) was available to cows at all times, regardless of the type of mineral supplement offered. Under those conditions, intake of a low-protein, molasses-based mineral supplement was approximately one-half that of a similar product consumed by the beef cows in our study. Interestingly, intake of the molasses-based protein supplement by beef cows in the study reported by Bailey and Welling (2007) was greater when a conventional, dry mineral supplement was offered to cows than when a low-protein, molasses-based mineral supplement was offered to cows. These authors concluded that molasses-based supplements (i.e., those with a sweet flavor), regardless of whether they were designed to deliver protein or minerals, were more attractive to grazing beef cows than conventional, dry mineral supplements based on salt.

Because of the nature of the molasses-based carrier, the sweet supplement contained small amounts of protein (i.e., 4%) and crude fat (i.e., 3%), whereas the salty supplement did not (Table 1). We considered the possibility that these minor differences in nutrient content may have influenced mineral-supplement intake in our study; however, little research has been conducted on this topic. Bailey and Welling (2007) reported that intake of a salt-free, low-protein, molasses-based mineral supplement (112 g·cow⁻¹·d⁻¹) by beef cows fed hay was numerically similar to the combined intakes of conventional, dry mineral and plain salt (106 g·cow⁻¹·d⁻¹). Conversely, intakes of salt-free, low-protein, molasses-based mineral supplement and conventional, dry mineral + salt were not similar when cows grazed native range (107 and 47 g·cow⁻¹·d⁻¹, respectively). We interpreted this information to suggest that more research is needed to determine whether small amounts of CP and fat, per se, contributed to the differences in mineral supplement intake that we observed.

It is common practice in the North American beef industry to supply NaCl ad libitum to grazing cattle. This was not done in our study because we wanted to make a direct comparison of the relative attractiveness of a sweet vs. a salty basis for mineral supplements; therefore, our results must be interpreted in light of this. We assumed that the appetite of each animal for salt could be satisfied through the continual availability of the salt-based, dry, granular mineral. It has been suggested that grazing cattle require little supplemental salt in addition to that present in forage and trace-mineral supplements; however, they may still exhibit a significant appetite for supplemental salt (Skovlin, 1965; Bryant, 1982). Schauer et al. (2004) reported that voluntary intake of a salt-limited supplement by grazing beef cattle increased with advancing season. These authors attributed this finding to either changing nutrient composition of available forage or a greater appetite for salt as forage quality declined. In spite of these observations, the appetite for salt per se may not strongly influence grazing distribution. Several groups of researchers reported that strategic placement of salt alone had limited effects on grazing patterns of livestock (Bryant, 1982; Ganskopp, 2001; Bailey and Welling, 1999, 2007). Bailey et al. (2008) found cattle spent less time resting, spent more time at higher elevations, and ventured farther from water when both a low-moisture block and salt were available compared with
when salt alone was available. Bryant (1982) suggested that cattle use salt when it is convenient, but not to alter their grazing patterns to obtain it. Consequently, there may be little or no synergy for altering grazing distribution when colocating salt and a molasses-based mineral carrier.

Greater consumption of the sweet supplement in study 1 was associated with more frequent \((P = 0.02\); Figure 3) herd visits to sites where the sweet supplement was deployed compared with sites where the salty supplement was deployed. Additionally, herd visits to the sweet sites were longer \((P < 0.01\); Figure 4) than those to the salty sites during study 1.

Bailey et al. (2008) reported that the duration of nighttime visits to molasses-based supplements was greater than that for white-salt blocks; however, the total length of evening visits \((1800 \text{ to } 0600 \text{ h})\) to the sweet supplement in study 1 was similar \((P = 0.16)\) to that for the salty supplement \((15.7 \text{ vs. } 12.2 \text{ h/d, respectively; data not shown}).

During study 2, the frequency of herd visits to the sweet and salty sites was similar during data collection periods conducted from June through mid-September; however, herds visited the sweet supplement almost twice as often as salty during late September \(\text{treatment } \times \text{ period interaction, } P < 0.01\); Figure 5).

Overall, it appeared that herds visited the sweet sites more frequently when forage quality was relatively poor and forage was possibly less palatable. Bailey and Welling (2007) and Bailey et al. (2008) concluded that molasses-based blocks designed to deliver either supplemental minerals or supplemental CP were more attractive to cattle during periods of poor forage quality when compared with periods of relatively good forage quality.

Herd visits to sweet sites in study 2 were longer than those to salty sites \((P < 0.01; \text{Figure 6)}\). The average duration of herd visits to the salty sites was numerically similar during studies 1 and 2 \((54.9 \text{ vs. } 51.4 \text{ min/herd visit, respectively); however, the duration of herd visits to sweet appeared to be numerically longer during study 1 compared with study 2 \((125.7 \text{ vs. } 83.8 \text{ min/herd visit, respectively)\). Cattle may have been less motivated to loiter in the vicinity of molasses-based mineral supplements during summer, when forage was of relatively high quality, compared with winter. Conversely, time spent around granular mineral supplements appeared to be fairly consistent between summer and winter.

The total length of nighttime visits \((1800 \text{ to } 0600 \text{ h})\) to the sweet sites in study 2 was greater \((P < 0.01)\) than that for salty \((13.4 \text{ vs. } 11.3 \text{ h/d, respectively; data not shown}). More time spent in the vicinity of sweet compared with salty at night may have influenced the location at which herds initiated grazing the following morning. Bailey et al. (2008) noted that cows bedded and rested near locations where molasses-based supplements were provided.

There was only a 4- to 12-h lag time in studies 1 and 2 between when either supplement was moved to a new location at the beginning of each collection period and when the cattle found and began to consume it, as evidenced by the time-and-date stamps on photographs collected with motion-activated cameras (data not shown). Therefore, we concluded that differences in the visual appearance of the vessels used to deliver mineral supplements had little influence on mineral intake, frequency of herd visits, or duration of herd visits.

Change in average forage disappearance from within a 100-m radius of supplement-deployment sites, as measured using a visual obstruction technique, was not influenced \((P \geq 0.54)\) by treatment during study 1 \((843 \text{ and } 749 \text{ kg of DM/ha for salty and sweet supplements, respectively})\) or study 2 \((516 \text{ and } 513 \text{ kg of DM/ha for salty and sweet supplements, respectively; data not shown}). Under the conditions of forage-availability measurement, more frequent and longer herd visits to sweet sites did not appear to negatively affect herbage availability compared with the salty sites. There
were 14 d between the initial and the final measurement of standing forage biomass during each period in both of our studies. Therefore, measurements of forage disappearance were complicated by rapid forage growth during data-collection periods conducted in May, June, and July. More frequent measurement of forage availability may be warranted in future trials to evaluate possible treatment differences in forage disappearance.

We concluded that sweet-flavored mineral supplements delivered in block form influenced the activities of grazing cows more strongly than salty-flavored mineral supplements delivered in granular form under the conditions of our study. These influences extended to the amount of supplement consumed as well as to the frequency, duration, and timing of use. Slight differences in the visual appearance of the vessels used to deliver mineral supplements had no influence on herd capabilities to locate and use supplements; variation in mineral consumption from animal to animal was not addressed. Results from the studies were interpreted to suggest that, without the provision of white salt, molasses-based supplements may be more effective than salt-based, granular mineral supplements at enticing grazing cattle into specific areas of topographically rugged native pastures during the winter, spring, and early fall.

**LITERATURE CITED**


Aubel et al.


