INFLUENCE OF SUPPLEMENTATION METHOD ON FORAGE USE AND GRAZING BEHAVIOR BY BEEF CATTLE GRAZING BLUESTEM RANGE

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ABSTRACT

Two 25-d trials (late summer and early winter) were conducted to determine the influence of supplementation method on forage use and grazing behavior. Fifteen ruminally and 12 esophageally fistulated steers (316 and 400 kg, respectively) were blocked by weight and assigned randomly to one of three treatments: 1) self-feeding supplement (via Calan gates) with salt as a limiting agent; 2) daily hand-feeding supplement plus salt; and 3) daily hand-feeding supplement without salt. Supplement intake was restricted to .95 kg steer-1.d-1 with .23 and .40 kg of salt steer-1.d-1 during summer and winter, respectively. Neither season nor supplementation method affected forage (1.64% of BW) or total (1.89% of BW) OM intake (P > .10). Total OM digestibility was greater (P < .05) in the summer, in salt-supplemented steers, and when steers were self-fed supplement. Digestibility of NDF was greater (P < .05) in the summer than in early winter, but did not differ among treatments (P > .10). Fluid dilution rate was greater (P < .05) for salt-fed and self-fed steers during the summer but similar among treatments (P > .10) during the winter. Total VFA concentrations did not differ among treatments during summer, but were slightly greater (P = .07) in hand-fed steers during the winter. Steers fed supplements containing salt consistently displayed lower (P < .01) acetate:propionate ratios, and self-fed steers had lower (P < .01) acetate:propionate ratios during the summer. Ruminal ammonia concentrations did not differ (P > .10) among treatments and between periods. Grazing time and distance travelled were similar among treatments (P > .10) but both were greater (P < .01) in summer than in winter. In summary, supplementation method occasionally influenced forage use but seemed to exert little influence on the components of grazing behavior measured.

Key Words: Self Feeding, Supplements, Salt, Forage, Intake, Digestion


Introduction

Beef cattle grazing native range are often fed supplemental protein. Increased gain by growing cattle and improved cow BW and condition during the wintering period have resulted from feeding supplemental protein (McCollum et al., 1985; DelCurto et al., 1990a). Increased forage intake (McCollum and Galyean, 1985) and increased forage digestibility (Church and Santos, 1981) may be largely responsible for the observed benefits of protein supplementation.

Self feeding a protein supplement with salt used as the limiting agent has improved cattle distribution on rangeland (Ares, 1953). In addition, self feeding a salt-limited protein supplement to beef cows supported a level of performance similar to daily hand feeding of the supplement (Riggs et al., 1953). Although some data are available regarding the influence...
of altering frequency of protein supplementation on intake and digestibility of low-quality grass hay (Hunt et al., 1989), little information is available concerning effects of self feeding a salt-limited protein supplement on utilization of native range forage. Therefore, our experiment was undertaken: 1) to determine effects of self feeding, as opposed to hand-feeding supplement, on forage utilization and grazing behavior; 2) to determine effects of salt on forage utilization and grazing behavior, and 3) to determine effects of season (late summer vs early winter) on forage utilization and grazing behavior of beef steers grazing bluestem range.

Materials and Methods

Fifteen ruminally and 12 esophageally fistulated steers of primarily Hereford × Angus breeding (average BW = 316 and 400 kg, respectively) were blocked by weight at the beginning of the late summer trial and assigned randomly to three treatments. The late summer trial was conducted from August 22 to September 18, 1988 and the early winter trial from December 26, 1988 to January 22, 1989. To determine effects of season on the measurements taken, steers were not rerandomized for the winter period but remained on the same treatments.

Treatments in these two trials consisted of 1) a self-feeding supplement (via Calan gates) with salt as the intake-limiting agent (SFS), 2) a daily hand-feeding supplement with salt (HFS), and 3) a daily hand-feeding supplement without salt (HNS). Supplement (DM basis) was a soybean meal (49.5%); grain sorghum (49.4%) mix, containing approximately 28% CP. Soybean oil (9.4%) was added to reduce dustiness and a trace mineral mix was added at .16% of the total supplement. Steers on the SFS treatment were adapted gradually to the Calan gates over a period of 3 to 4 wk. During adaptation, level of salt in the supplement was adjusted to determine the level needed to limit intake of the basal supplement to approximately 1 kg-steer−1·d−1. Steers in HFS and HNS groups also were acclimated to supplements during this period. During the summer period, this level was determined to be .23 kg of salt-steer−1·d−1, which resulted in salt composing 19.5% of the total supplement. This same adaptation process was undertaken for the winter period; however, because of previous experience, only 2 wk were needed for SFS steers to become accustomed to the feeders. Probably because of the lower quality of the forage in the winter period, it was necessary to increase the salt in the supplement to .40 kg of salt-steer−1·d−1, or 29.6% salt, to maintain supplement consumption at approximately 1 kg-steer−1·d−1. When SFS steers were accustomed to the Calan gates and the level of salt had been established, the formal adaptation period was begun. Supplement intake by the SFS group was determined by weighing daily supplement refusals. To ensure that supplement intake was equal among treatments, average intake by the SFS group was fed to each of the HFS and HNS groups. The HFS group received the same amount of supplement and salt as the SFS group, whereas the HNS group received only the same amount of supplement (no salt). Hand feeding of supplements took place from approximately 1200 to 1400 daily. Steers on the HFS and HNS treatments were gathered daily at 1200, tied, and individually fed their supplement in 30.5-cm × 76-cm rubber tubs. To maintain equal supplement intakes across all treatments, any refused feed was fed by force to the HFS and HNS steers, either by removing the cap of the ruminal cannula and administering the feed intraruminally or by administering the remaining material via the esophageal fistula in the case of esophageally fistulated steers.

Steers grazed three contiguous bluestem-range pastures of approximately 4 ha each. Vegetation in the pastures consisted of big bluestem (Andropogon gerardii), little bluestem (Schizachyrium scoparium), indiangrass (Sorghastrum nutans), asters (Aster spp.), goldenrods (Solidago spp.), and other less prominent grasses and forbs (Anderson and Owensby, 1969). No precipitation occurred during the summer period, and only traces occurred during the winter period. Minimum and maximum temperatures were 14 and 34°C (summer period) and −9 and 17°C (winter period), respectively. Although forage availability was not measured, visual evaluation of the pastures indicated that quantity of forage was not limiting during either period. To maintain the behavioral identity of each

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7American Calan, Inc., Northwood, NH.
8Contained Ca (≥ 4%, ≤ 5%), Fe (≥ .10%), Zn (≥ .10%), Mn (≥ .10%), Cu (≥ .10%), I (≥ .003%), and Co (≥ .001%).
treatment, the three groups were maintained separately but were rotated among pastures twice weekly. Each pasture contained a water tank that was placed either in or adjacent to a central corral that also housed the Calan gates. Gates were sheltered by a small shed.

Each 25-d period included a 7-d adaptation period, a 7-d behavior-observation period, a 3-d esophageal collection period (concurrent with the behavior-observation period), a 7-d total fecal collection period, a 1-d ruminal evacuation period, a 1-d rest period, and a 24-h ruminal sampling period. Included in the 7-d behavior-observation period was a 72-h period during which the SFS group was continually observed, to determine the time of day and frequency with which steers used the Calan gates. During the esophageal collection period, in order to minimize possible pasture effects, each group grazed each pasture. Esophageal samples were collected at 0700 daily and frozen. On d 22, ruminal contents were evacuated just before supplementation, weighed, mixed by hand, subsampled, and returned to the animal. Supplement samples were collected daily. Total fecal output was measured via fecal collection bags; daily samples were taken during the 7-d fecal collection period.

Feed, fecal, and ruminal evacuation samples were dried at 55°C in a forced-air oven, whereas esophageal samples were freeze-dried. All samples were ground to a 1-mm screen in a small-sample mill and composited within animal; duplicate samples were analyzed for DM and ash by standard procedures (AOAC, 1984). Indigestible ADF (IADF) contents of supplement, fecal, and esophageal samples were determined by a 144-h in vitro fermentation followed by ADF extraction (Cochran et al., 1986); plastic centrifuge tubes were used instead of glass screw-cap tubes. Neutral detergent fiber contents of supplement, fecal, and esophageal samples were determined by the modified procedure of Robertson and Van Soest (1981). Kjeldahl N (AOAC, 1984) and acid detergent lignin contents (Goering and Van Soest, 1970) of esophageal samples was determined in duplicate.

Following the rest period after ruminal evacuations, steers were pulse-dosed with CoEDTA at 0800 on d 24 to estimate ruminal fluid dilution rate and volume (Uden et al., 1980). Each dose of 2.5 g of Co was dissolved in 250 ml of distilled water and injected into several ruminal sites with a repeating syringe. Ruminal fluid samples were collected at various locations in the rumen using a suction strainer before dosing (0 h) to provide a background matrix for Co analysis in addition to baseline values for pH, ammonia N (NH₃-N), and VFA. Subsequent ruminal fluid samples were collected at 3, 6, 9, 12, and 24 h after dosing. Steers were supplemented after the 6-h sampling period. Ruminal pH was determined immediately after sampling using a combination electrode. Samples for NH₃-N and VFA analysis were frozen (~20°C) after treatment with .1 N HCl (2 ml plus 2 ml of ruminal fluid) and 25% metaphosphoric acid (1 ml plus 4 ml of ruminal fluid), respectively.

Ruminal fluid samples were centrifuged before analysis at 39,000 × g for 20 min. Ruminal NH₃-N concentrations were determined on an autoanalyzer using a hypochlorite method (Broderick and Kang, 1980). Ruminal VFA were determined using gas chromatography (Jacques et al., 1987). Ruminal Co concentrations were determined using atomic absorption spectroscopy with an air plus acetylene flame. Calculation of ruminal fluid volume and dilution rate was based on regression (Warner and Stacy, 1968). Ruminal DM fill was determined by manual evacuation of ruminal contents just before supplementation. Forage OM intake was determined using the internal marker ratio procedure for estimating diet digestibility; IADF was used as the internal marker. Calculations of total diet and forage OM intake were determined as described by Kartchner (1980), using TDN values as estimates of supplement digestibility (NRC, 1984).

All ruminally fistulated steers in each treatment were used to evaluate grazing behavior. Steers were fitted with vibracorders (Stobbs, 1970) during the 7-d grazing behavior period to monitor grazing time and pattern. Interpretation of vibracorder charts was similar to that described by Adams et al. (1986). In addition, steers were fitted with digital pedom-
terts to determine distance travelled (Anderson and Kothmann, 1977). Digital pedometers were calibrated by walking the steers a known distance, recording the reading, and calculating appropriate correction factors. During the 72-h visual observation, time of day that the SFS steers visited the Calan gates, and time that they spent eating, were recorded for each steer. Amount of time spent in the pen also was recorded. Care was taken not to disturb or distract the steers during observations.

All data were analyzed using the GLM procedure of SAS (1985). Data pertaining to intake, digestibility, and diet selection were analyzed as a split-plot analysis of variance. Terms in the model were treatment, block, treatment × block, period, and treatment × period. Treatment × block was used to test treatment effects and the residual error was used to test the period and treatment × period effects. Ruminal fermentation characteristics and behavior observation data were analyzed by a split-split plot analysis of variance. Terms in the model were treatment, block, treatment × block, period, treatment × period, treatment × block × period, sampling time, treatment × sampling time, period × sampling time, and treatment × period × sampling time. Treatment × block was used to test the treatment effect, treatment × block × period was used to test period and treatment × period effects, and the residual error was used to test the sampling time effect and associated interactions. Variables that exhibited a significant (P < .05) three-way interaction were analyzed within period. If a treatment × sampling time interaction (P < .05) existed, variables were further analyzed within time. Because all animals were fed individually, steer was considered the experimental unit. Means were separated using preplanned, linear contrasts. Contrasts were constructed to compare 1) including salt in the supplement with no salt in the supplement and 2) self-feeding vs hand-feeding supplements.

Results and Discussion

Diet Quality. Interactions among treatments and between seasons were not evident (P > .05) for chemical composition of esophageal masticate. Chemical composition of the selected forage (Table 1) was not significantly altered by supplementation method, except for NDF concentration. In this instance, NDF concentration was less (P = .03) for the steers with salt in their supplement and for self-fed than for hand-fed steers (P = .05). Although some previous research indicates that the potential exists to modify diet selection via energy or protein supplementation (Jung and Koong, 1985; DelCurto et al., 1990a), other research has reported little or no effect of protein supplementation on diet selection (Judkins et al., 1985; Caton et al., 1988). We interpret the data from our study to indicate that self feeding a salt-limited supplement has the potential to elicit slight improvements in quality of diet selected; however, the mechanism responsible for such an effect is unclear. Although ADL concentration was not significantly affected by supplementation treatment, it tended (P = .10) to vary inversely with NDF concentration. Although not statistically significant, numerical differences of similar pattern and magnitude have been reported by Judkins et al. (1985) and Caton et al. (1988). Judkins et al. (1985) suggested that differences of this nature might occur with changes in botanical composition of diet selected (e.g., shifts in the amount of forbs consumed).

As rangeland forages increase in maturity, their quality declines; the fiber content increases and CP content decreases (Ball et al., 1978). Likewise, NDF content in the present study was greater (P < .01) in the winter than in the summer. In a similar manner, ADL content in the selected forage was 29% greater (P < .01) in the winter. Campbell and McComb (1988) reported that as the season progresses, potentially digestible protein and total N concentration in range forage decreases. Data from our study concur with this observation, in that the CP content of the selected forage was greater (P < .01) in summer than in winter. In addition, the ADIN concentration increased (P < .01) by 38% in the winter period. Consistent differences in chemical composition of grazed forage among seasons, and the variable response to supplementation method, suggests that season played a greater role in influencing quality of diet selected than did supplementation method.

Intake and Digestibility. Interactions between treatments and season were not evident (P > .10) for intake and digestibility measurements. Forage and total OM intake, expressed as a percentage of BW, did not differ (P > .10) among treatments or between seasons. Addition of 227 g of salt to silage or low-quality hay diets of growing beef steers did not
Forage composition, expected to decrease. Absence of the range grasses, forage intake would be NDF Digestion, 4132 BRANDYBERRY the onset of winter and the reduced quality of Level of salt offered to steers in our trial, levels of forage intake reported in our experience, giving the potential of the low intake level to care should be exercised in attempting to extrapolate these data to conditions in which the basal level of forage intake is considerably greater. Basal supplement intake in our study, when expressed as a percentage of BW, was slightly less in the winter (P < .01) than in summer; however, steers weighed nearly 80 kg more during the winter, although basal supplement intake was held at the same amount fed during the summer (.95 kg-steer\(^{-1}\cdot d^{-1}). With the onset of winter and the reduced quality of the range grasses, forage intake would be expected to decrease. Absence of a response to season in our trial may have resulted from the fact that all steers received a protein supplement during each period, which had the potential to enhance intake (McCollum and Galwayne, 1985; DelCurto et al., 1990b). In addition, a mild, dry winter may have reduced potential seasonal differences. Total diet OM digestibility was greater for steers receiving salt in their supplement (P < .01) and in self-fed steers (P = .02). These results agree with those of Riggs et al. (1953), who noted an 8% increase in protein digestibility and a 5% increase in both crude fiber and NFE digestibility when cows received a cottonseed meal-salt supplement compared with cows receiving cottonseed meal only. Part of the increase in digestibility noted in our study may have been the result of influences on microbial growth and activity. Sodium is required by anaerobic ruminal bacteria (Caldwell and Hudson, 1974); deleting Na from an otherwise nutritionally adequate medium eliminated microbial growth (Caldwell and Hudson, 1974). The HNS group did not have access to salt during the two trials. Because bluestem-range forage is deficient in Na (yearly mean of .01% Na; Umoh et al., 1982), lack of salt in the diet could have influenced microbial numbers and activity. Nonetheless, NDF digestibility did not differ among treatment groups (P > .10). A likely contributor to

**TABLE 1. INFLUENCE OF SUPPLEMENTATION METHOD AND SEASON ON CHEMICAL COMPOSITION OF ESOPHAGEALLY COLLECTED FORAGE SAMPLES, INTAKE, DIGESTION, FILL, AND GRAZING BEHAVIOR**

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatments(^a)</th>
<th>Contrasts(^b)</th>
<th>Season</th>
<th>Season effect(^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SFS</td>
<td>HFS</td>
<td>HNS</td>
<td>SE</td>
</tr>
<tr>
<td>Forage composition, % of OM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>7.2</td>
<td>6.5</td>
<td>6.7</td>
<td>.35</td>
</tr>
<tr>
<td>NDF</td>
<td>70.5</td>
<td>72.4</td>
<td>74.6</td>
<td>1.07</td>
</tr>
<tr>
<td>ADL</td>
<td>7.0</td>
<td>6.3</td>
<td>6.0</td>
<td>.33</td>
</tr>
<tr>
<td>ADIN</td>
<td>.19</td>
<td>.18</td>
<td>.19</td>
<td>.01</td>
</tr>
<tr>
<td>Organic matter intake, % of BW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forage</td>
<td>1.68</td>
<td>1.56</td>
<td>1.69</td>
<td>.08</td>
</tr>
<tr>
<td>Supplement</td>
<td>.26</td>
<td>.24</td>
<td>.24</td>
<td>.05</td>
</tr>
<tr>
<td>Total</td>
<td>1.94</td>
<td>1.81</td>
<td>1.92</td>
<td>.09</td>
</tr>
<tr>
<td>Organic matter digestion, %</td>
<td>62.3</td>
<td>60.8</td>
<td>58.2</td>
<td>.79</td>
</tr>
<tr>
<td>NDF Digestion, %</td>
<td>59.0</td>
<td>59.2</td>
<td>58.3</td>
<td>.89</td>
</tr>
<tr>
<td>Fluid fill, liters</td>
<td>54.6</td>
<td>53.0</td>
<td>54.5</td>
<td>2.56</td>
</tr>
<tr>
<td>Dry matter fill, kg</td>
<td>17.7</td>
<td>16.6</td>
<td>18.7</td>
<td>1.02</td>
</tr>
<tr>
<td>Distance travelled, km/d</td>
<td>3.46</td>
<td>3.32</td>
<td>3.20</td>
<td>.11</td>
</tr>
<tr>
<td>Time spent grazing, h/d</td>
<td>8.42</td>
<td>8.36</td>
<td>8.74</td>
<td>.47</td>
</tr>
</tbody>
</table>

\(^a\)SFS = self-fed a salt-limited supplement; HFS = hand-fed daily the same amount and type of supplement as the SFS treatment; HNS = hand-fed daily the same amount of supplement as SFS and HFS but without salt in the supplement.

\(^b\)Probability of observing a larger F-value. SvNS = comparison of supplements with salt vs those without salt. SFvHF = comparison of self-feeding the supplement with hand feeding the supplement.

\(^c\)Probability of observing a larger F-value.
the different results for NDF and OM digestibility is the difference in percentage NDF in diets selected by different treatment groups. Although NDF in the diet was digested to a similar extent, there was less \( P < .05 \) NDF in the diets of steers receiving salt in their supplement and for self-fed steers. Reduced total amount of dietary NDF corresponded to increased OMD. Both total OM and NDF digestibility were greater in summer than in winter \( P < .01 \). Likewise, Campbell and McCollum (1988) reported that increased fiber content of range forage, associated with decreased protein content, leads to decreased digestibility. Increased fiber concentration and decreased protein concentration in the grazed forage were observed during the winter period in our study.

Ruminal Fill and Fluid Flow. Interactions between treatments and season were not evident \( P > .05 \) for fill and fluid characteristics, except for fluid dilution rate \( (P = .04; \text{Table 2}) \). Ruminal fill of DM was not influenced by treatment \( (\text{average} = 17.7 \text{ kg}) \), although fill was slightly greater \( P < .01 \) during the summer than during the winter. Given that the steers' rumens were emptied at the same time of day in each period, slight differences in fill between seasons could simply reflect shifts in daily grazing patterns (percentage distribution) with season. Ruminal fluid fill was not influenced \( P > .10 \) by either treatment or season \( (\text{average} = 54.0 \text{ liters}) \). During the summer, ruminal fluid dilution rate was faster \( (P = .05) \) in steers receiving salt in their supplement and for self-fed steers \( (P = .01) \). During the winter period, however, neither including salt in the supplement \( (P = .68) \) nor self-feeding \( (P = .87) \) influenced fluid dilution rate. Thomson et al. (1978), Rogers et al. (1979), and Harvey et al. (1986) observed increased fluid dilution rate with the addition of salt to the diet. Harrison et al. (1975) also reported increased fluid dilution rate after infusions of hypertonic solutions in sheep. Rogers et al. (1979) attributed changes in ruminal outflow on roughage-based diets to elevated ruminal osmolality and increased water consumption with increased levels of salt infusion. Hot, sultry weather occurred during the summer trial, and although water consumption was not measured, it was observed to be quite high, which may have been a factor contributing to the difference in fluid dilution rate during the summer. The reason for the differences between the SFS and hand-fed steers is not clear; however, variation in patterns and(or) amount of water consumption may have contributed to the effects observed.

Ruminal Fermentation Characteristics. Although significant three-way interactions were evident for most ruminal fermentation charac-

TABLE 2. INFLUENCE OF SUPPLEMENTATION METHOD AND SEASON ON FLUID DILUTION RATE AND RUMINAL FERMENTATION CHARACTERISTICS

<table>
<thead>
<tr>
<th>Item</th>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SFS HFS HNS SE</td>
<td>SFS HFS HNS SE</td>
</tr>
<tr>
<td>Fluid dilution, %\text{h}</td>
<td>12.3 10.0 9.3 .66 .05 .01</td>
<td>8.9 9.2 8.8 .45 .68 .87</td>
</tr>
<tr>
<td>NH\text{3}-N, mM</td>
<td>2.3 2.2 1.8 .50 .53 .60</td>
<td>2.3 1.3 2.1 .38 .51 .23</td>
</tr>
<tr>
<td>pH</td>
<td>6.5 6.6 6.7 .06 .06 .18</td>
<td>6.4 6.5 6.8 .07 .01 .06</td>
</tr>
<tr>
<td>Total VFA, mM</td>
<td>83.8 81.2 76.6 3.41 .20 .28</td>
<td>63.8 70.3 66.7 1.86 .89 .07</td>
</tr>
<tr>
<td>Acetate\text{c,d}</td>
<td>74.3 74.9 76.6 .50 .01 .05</td>
<td>72.1 75.0 75.1 1.69 .49 .19</td>
</tr>
<tr>
<td>Propionate</td>
<td>14.8 13.7 12.5 .32 &lt;.01 &lt;.01</td>
<td>16.3 16.4 15.0 .29 &lt;.01 .12</td>
</tr>
<tr>
<td>Butyrate</td>
<td>9.1 9.6 9.1 .26 .60 .38</td>
<td>7.4 7.0 8.2 .27 .01 .52</td>
</tr>
<tr>
<td>Isobutyrate</td>
<td>.6 .6 .6 .04 .86 .95</td>
<td>.5 .6 .6 .02 .50 .75</td>
</tr>
<tr>
<td>Valerate</td>
<td>.6 .6 .6 .02 .02 .05</td>
<td>.5 .5 .5 .01 .02 .02</td>
</tr>
<tr>
<td>Isovalerate</td>
<td>.6 .6 .6 .08 .68 .82</td>
<td>.4 .5 .5 .04 .7 .18</td>
</tr>
<tr>
<td>Acetate:propionate</td>
<td>5.1 5.6 6.2 .17 &lt;.01 &lt;.01</td>
<td>4.6 4.6 5.0 .10 &lt;.01 .13</td>
</tr>
</tbody>
</table>

\( ^a \text{SFS = self fed a salt-limited supplement; HFS = hand fed daily the same amount of supplement as the SFS treatment; HNS = hand fed daily the same amount of supplement as SFS and HFS but without salt in the supplement.} \)

\( ^b \text{Probability of observing a larger } F \text{-value. SvNS = comparison of supplements with salt vs those without salt. SFvHF = comparison of self feeding the supplement with hand feeding the supplement.} \)

\( ^c \text{Individual VFA are expressed as mol/100 mol.} \)

\( ^d \text{No time or period effect } (P > .10). \text{Main affect means were 75.3 and 74.1 for summer and winter, respectively, and 73.2, 75.0, and 75.9 for SFS, HFS, and HNS, respectively.} \)
teristics, inspection of the data suggested that the interactions largely reflected changes in the magnitude of differences rather than changes in the manner in which treatments responded over time; therefore, data were pooled across sampling times. Significant treatment × season interactions (P < .05) were evident for all fermentation variables except acetate. Molar proportions of acetate did not differ between seasons (P = .24). When values were averaged across seasons, hand-fed steers displayed greater (P = .03) molar percentages of acetate than SFS steers, although including salt in the supplement only tended (P = .08) to decrease the molar percentage of acetate. For propionate, SFS and HFS groups had greater (P < .01) molar proportions in the ruminal fluid and, during the summer, molar proportion of propionate was greater (P < .01) in SFS steers than in the HFS and HNS groups. Although not statistically significant, this same trend also was evident (P = .12) during the winter. Acetate:propionate ratio basically mirrored the propionate trends; it was generally least in SFS and HFS groups and, during the winter, was less for SFS compared with hand-fed groups. Although Rogers et al. (1979) and Rogers and Davis (1982) reported that steers fed high-concentrate diets exhibited decreased molar proportions of ruminal propionate and increased fluid dilution rate after infusion of a hypertonic salt solution, they noted that propionate proportions in roughage-fed steers were not affected by salt infusion, even when accompanied by increased fluid dilution rate. The moderate change in fermentation patterns noted in our study may relate to the slightly lower amount of NDF in the diet selected, and the availability of salt, while consuming a Na-deficient forage, for the two groups receiving salt-containing supplements (SFS and HFS). Both butyrate proportion and total VFA concentration were similar among treatments during the summer period. During the winter, however, butyrate proportions were greater (P = .01) when salt was included in the supplement, and total VFA concentration was slightly greater (P = .07) in hand-fed vs SFS steers. In general, total VFA concentration was greater in the summer; this would be expected given the greater extent of forage digestion during the summer period.

When cattle graze low-quality forage that is low in protein, addition of a high-quality protein supplement provides, among other things, precursors for the production of branched-chain VFA. Many ruminal bacteria have a requirement for these VFA, which serve important roles in the resynthesis of corresponding amino acids and in the synthesis of long-chain fatty acids (Yokoyama and Johnson, 1988). In general, valerate was the only branched-chain VFA that showed treatment effects during the summer, whereas isobutyrate was the only branched-chain VFA that showed treatment effects during the winter. No explanation is readily apparent for the erratic nature of the observed changes; however, the magnitude of the changes is such as to suggest that they would exert minimal impact on diet utilization.

In general, HNS steers had slightly greater (P < .06) ruminal pH than SFS and HFS steers. In addition, SFS steers had a slightly lower (P = .06) ruminal pH than HFS and HNS steers during the winter. Although these differences in pH were statistically significant, they probably have limited biological significance given that pH values for all treatments were above that at which one would expect depression of fiber degradation by cellulolytic bacteria (Owens and Goetsch, 1988).

Although optimal levels for ruminal NH₃-N remain controversial, it is known that microbial requirement for NH₃-N is influenced by substrate availability and fermentation rate (NRC, 1985). Ørskov (1982) implied that lesser amounts of NH₃-N were required by microorganisms to maximize rate of digestion for low-quality, fibrous feedstuffs than for high-concentrate diets. Ruminal NH₃-N concentrations in our study did not differ (P > .10) among treatments or between periods and were relatively low (2.0 mM). However, given the levels of OM and NDF digestion observed in these trials, protein provided by the supplement seemed to provide adequate ruminal NH₃-N to support fermentation of the basal forage.

Grazing Behavior. Distance travelled (km/d) was not influenced by treatment (P > .10); however, during the summer, steers travelled an average of 1 km/d further than in the winter (P < .01). Similarly, the amount of time steers spent grazing did not differ among treatments (P > .10), but varied between seasons; steers grazed an average of 1.14 h/d more (P < .01) during the summer; the heaviest grazing periods occurred during midmorning (0600 to 0900) and late afternoon (1500 to 1800). There
also were periods of night grazing, which agrees with data from Stobbs (1970) and Stricklin et al. (1976). Adams et al. (1986) found that cows spent less time grazing and reduced their intake of range forage during cold winter periods. Although no adverse winter weather was encountered during our study, shorter days, colder temperatures, and lower forage quality seemed to combine to reduce amount of time spent grazing.

Data from the 72-h visual observation periods indicated that SFS steers typically visited the self-feeders only once or twice daily. The primary time for self supplementation occurred during the middle of the day (Figure 1), which coincided with periods of less-active grazing for all treatment groups. Steers also occasionally visited the self-feeders in the midmorning; however, this period was minor compared with midafternoon feeding and usually involved more aggressive steers. Feeding bouts at the self feeders were typically short, and, after a few minutes of feeding, SFS steers would spend a considerable amount of time resting in the area of the self feeders before drinking and returning to graze.

Implications

Self feeding a salt-limited supplement of moderate crude protein concentration (28%) to steers grazing bluestem range during late summer and early winter either had no effect or slight positive effects on forage utilization. In general, method of supplementation did not alter time spent grazing or distance travelled in small pastures. Thus, self-feeding supplements using salt as the limiting agent would not be expected to have a negative impact on animal performance and could result in a considerable savings in labor. Positive benefits noted when salt was included in the supplements underscore the importance of salt supplementation in sodium-deficient range environments. Finally, the lower quality of diet selected and lower forage digestibility during the winter than during summer agrees with numerous previous reports.

Literature Cited


