FACTORS AFFECTING FORAGING BEHAVIOR OF BEEF CATTLE GRAZING NATIVE
TALLGRASS RANGE IN THE KANSAS FLINT HILLS

by

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B.S., Kansas State University, 2002
MBA, Oklahoma State University, 2005

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Animal Sciences and Industry
College of Agriculture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2011

Abstract

The objective of this series of studies was to examine select factors that affect behavior of beef cattle grazing native-tallgrass rangelands. Mineral supplements with divergent palatability characteristics were delivered to beef cows grazing native tallgrass range during various seasons of the year in order to measure mineral intake, frequency of supplement use, and duration of supplement use. We concluded that molasses-based mineral supplements influenced the activities of grazing cows more strongly than salt-based mineral supplements. These influences extended to the amount of supplement consumed as well as to the frequency, duration, and timing of use. Diet selection preferences of experienced, multiparous beef cows and naïve, primiparous beef cows grazing dormant, native tallgrass pastures were examined also during a short-term winter grazing bout. Naïve, primiparous cows selected more forbs and fewer grasses than experienced, multiparous cows. Previous research indicated that preference for broadleaf plants generally increased with grazing experience; however, these conclusions were based on research with greater-quality forages than those evaluated in our study. The differences in diet selection patterns between experienced, multiparous cows and naïve, primiparous cows during a short-term winter grazing period could be indicative of differences in long-term foraging strategies. In addition, the botanical composition of diets grazed by lactating beef cows with suckling calves and non-pregnant, non-lactating beef cows grazing either burned or unburned native tallgrass prairie during summer were evaluated. There were no differences in botanical diet composition between lactating cows suckling calves and non-lactating cows. In contrast, total graminoid selection was greater on burned (74.2%) than unburned pastures (71.8%) and total forb selection was greater on unburned (28.2%) than burned pastures (25.8%). We interpreted these data to suggest that forage selection preferences of beef cows can be altered with spring burning of native tallgrass pastures. Effects of large, round hay bale feeding method on intake of smooth bromegrass hay and eating behavior by beef cows were examined on dormant tallgrass prairie pastures during winter. Three large, round hay bale-feeding systems were evaluated: bales fed in a ring feeder, bales unrolled on the ground, and bales chopped with a flail-type hay processor (20-cm particle length) and deposited on the ground. Hay intake, hay refusal, frequency of use, and duration of use were not influenced by hay-feeding method. Foraging behaviors of beef cows in our studies were influenced by supplement type, cow age, and prescribed burning of rangeland. Conversely, foraging behaviors of beef cows were not influenced by lactation or by hay-feeding method.

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Acknowledgements

There are many individuals that made this dissertation possible. First, I would like to thank my major professor, Dr. KC Olson, for believing in me and giving me the opportunity to come back to school to pursue a higher education. The countless hours you spent teaching me to become a better student, researcher, teacher, and scientist are greatly appreciated. Thank you for your patience, willingness to listen, and advice over the years. You, Karli, Charles, and Theodore will always have a special place in my heart. Thank you for everything you have done for me.

I would like to thank my committee members for their time and assistance with this degree. Thank you Dr. Dale Blasi, Dr. John Jaeger, Dr. Lily Edwards, and Dr. Walt Fick for your guidance and support during my program and making it a success. And thank you Dr. Dan Thomson for serving as my outside chairperson and facilitating my defense.

Thank you to all of my boys, Gary Ritter, and Wayne Adolph of the CCU for all of your help with my projects and fixing whatever piece of equipment I might have broken over the years! A special thank you goes out to my freshman, Robert Kreikemeier. Thank you Robert for all of your time and assistance with my first research project. Not only did you help me with my projects, but you also made me laugh and appreciate the innocence of being young. There is no better place to do research projects than the CCU. I will truly miss the days of feeding cows and riding the pastures of the CCU with all of you.

Thank you Greg Eckerle and Cheryl Armendariz for your assistance in the laboratory. Your skills and knowledge are greatly appreciated. And Greg, thank you for patience with me while working in the lab because we all know what a slow learner I was in the lab. Without you, my diet selection research would not have happened. For that, I am eternally grateful to you. Thank you Kayla Sprosty for helping me take the thousands of pictures for my research. And thank you Zach Murphy and Robert Kreikemeier for your help in the lab that summer.

I am very grateful for the assistance of my fellow graduate students. First, and foremost, thank you Callie Walker for welcoming me to grad school, answering my countless questions, and for being such a great friend. Thank you Arturo, Melissa, Michael, and Lauren for your friendship and all of your help on those cold mornings and hot afternoons at the CCU. Thank you Carrie, Sarah, and Kendra for being such great roommates and friends, making me laugh, and

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providing me with a lifetime of memories. And thank you Jeannine for your continued support and friendship.

Most importantly, I would like to thank my family. Thank you Mom and Dad for your encouragement, support, and love throughout my education and life. You have provided me with the opportunities to reach for the stars. You are a true inspiration. Thank you to my little brothers, Ross and Raymond, for your love and support. And last, but not least, thank you to my husband, Derek, for your continued love throughout this endeavor. Thank you for sticking out the distance between us as I finished my degree. You are my best friend, my rock, and the reason I wake up with a smile everyday.

Dedication

I dedicate my dissertation to my husband, Derek, and my parents, Bill and Peggy, for all of their love, support, and prayers.

Chapter 1 - **Review of Literature**

Introduction

Productivity of grazing-livestock enterprises is dependent upon the ability of domestic herbivores to efficiently graze available forage resources. Increased understanding of grazing distribution patterns will assist land managers in properly allocating forage resources while preserving the biotic integrity of rangelands. First, modifying grazing behaviors with strategic supplement placement can lead to improvements in grazing distribution. Second, identifying botanical diet composition and forage selection preferences can allow for more precise management of various classes of domestic herbivores. Selecting the type of grazing animal that is most compatible with the forage resource is vital for ecologically-sound management of rangelands. Third, a working knowledge of foraging behavior will allow predictions of how and where domestic herbivores choose to graze. This information may permit managers to alter grazing practices as needed to protect environmentally-sensitive range sites.

Altering Grazing Distribution via Strategic Placement of Supplements

Uneven grazing distribution can result in localized over- and under-grazing on native rangelands. Grazing animals tend to congregate and graze heavily in areas near water, shade, and on level terrain, while abundant forage remains on less-preferred range sites (Smith et al., 1992; Bailey, 2004). These negative effects can be minimized by preventing localized over-grazing (Pieper, 1994; Jones, 2000; Launchbaugh and Howery, 2005). Water development, cross-fencing, and herding exclude or minimize grazing activities in areas of rangeland preferred by cattle and can improve the overall uniformity of forage use in individual pastures (Skovlin, 1957; Cook, 1966; Kauffman and Krueger, 1984; Bailey and Rittenhouse, 1989; Bailey and Welling, 1999; Butler, 2000); however, these attempts to protect sensitive rangeland by modifying grazing activities tend to be costly and labor-intensive. An alternative means for modifying grazing patterns is with the use of strategic placement of supplemental feeds. Most commercially-available supplements have the potential to lure cattle into underutilized rangelands (Bailey, 2004). Strategic placement of supplements can be an effective, low-cost way to entice cattle into under-used and away from over-used areas of range and pasture (Porath et al., 2002; Bailey and Welling, 2007).

At certain times of the year, grazing cattle often do not receive enough nutrients from grazed forages to meet production goals (Bailey and Welling, 2007). Typically, protein supplementation is the first-limiting nutrient after forages reach reproductive maturity or dormancy (DelCutro et al., 2000); moreover, mineral supplementation is often provided to grazing cattle in order to maintain optimum reproductive performance immunity, lactation, or growth (Corah and Ives, 1991; Ansotegui et al., 1994; Greene, 2000; Swenson et al., 2000).

Bailey and Welling (1999) evaluated the effects of using a low-moisture, molasses-based supplement to modify grazing distribution of cattle during fall and early winter. Cattle spent more time grazing within 600 m of supplement-feeding sites than in similar areas with no available supplement. They suggested strategic placement of low-moisture, molasses-based supplements could be used to change grazing patterns of beef cows but cautioned that the technique may be more effective in moderate terrain than in rugged terrain. They recommended that the location where supplemental feeds were offered to grazing cattle be moved regularly to avoid localized overgrazing. New feeding sites should be at least 300 m away from previous sites to avoid degradation of nearby areas (Bailey, 2004).

Bailey and Jensen (2008) reported that strategic placement of low-moisture, molasses based supplements was a more practical and effective method for altering grazing patterns of beef cows maintained on rugged terrain than traditional hand-feeding of range cake. Cows spent 5 h/d within 100 m of the low-moisture, molasses based supplements and had more incentive to return to these sites compared to range-cake feeding sites where cattle spent less than 1 h/d. Furthermore, the authors concluded that the strategic placement of low-moisture blocks increased grazing on steep slopes that typically received little grazing pressure.

Bailey et al. (2008a) evaluated the efficacy of supplement placement and low-stress herding to manage grazing in riparian areas. The authors concluded that strategic placement of low-moisture, molasses-based supplements did not reduce the time cattle spent grazing near streams; however, it increased forage utilization in upland areas within 600 m of feeding sites.

Bailey and Welling (2007) evaluated grazing patterns of beef cows when supplemental minerals were offered as low-moisture, molasses-based blocks or conventional, granular mixes. Cattle spent more time and made more frequent visits to the supplement feeding sites where the low-moisture, molasses-based mineral was available compared to sites where conventional, granular mineral was available. Similarly, Bailey and Welling (2002) reported that cows visited

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supplement-feeding sites where low-moisture, molasses-based mineral supplements were available more frequently and spent more time within 100, 200, 400, and 600 m of those sites than supplement-feeding sites where conventional, granular mineral was available. Bailey et al. (2001) reported forage utilization by beef cows was uniform within a radius of 600 m from the location of a low-moisture, molasses-based mineral supplement. Bailey and Welling (2002, 2007) concluded that low-moisture, molasses-based blocks were more attractive to grazing beef cattle than conventional, granular mineral mixes and produced stronger changes in cattle behavior.

Strategic placement of salt alone has been used in an attempt to alter the distribution of grazing cattle (Porath et al., 2002; Bailey and Welling, 2007). Cattle consumed salt in excess of their requirements when given unlimited access; however, salt placement did not affect where cattle grazed (Bailey and Welling, 1999). Similarly, 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, 2007). 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) demonstrated that voluntary intake of a salt-limited supplement by grazing cattle increased with advancing season. These authors attributed the increased appetite for salt to changing nutrient composition of available forage. Beeson et al. (1957) suggested that salt levels in self-fed supplements need to be adjusted to compensate for changing palatability characteristics of forage. Bailey et al. (2008b) found cattle spent less time resting, spent more time at higher elevations, and ventured further from water when both a low-moisture, molasses-based supplement and salt were co-located in rugged terrain compared to when salt alone was offered in rugged terrain. Bryant (1982) suggested cattle use salt when it is convenient, but do not alter their grazing patterns to obtain it. Therefore, there may be little or no synergy for altering grazing distribution when co-locating salt and a molasses-based mineral carrier.

Grazing Behavior

Bailey and Rittenhouse (1989) suggested grazing distribution of domestic herbivores is based on a multi-level response to the grazing environment. An animal's decision about where,

when, and how to graze is based on perception, knowledge, and memory of potential choices. Memory may be the most critical component of long-term foraging success. Provenza and Balph (1990) reported animals grazing on unfamiliar rangelands consumed less forage, spent more time walking, and suffered more often from malnutrition and predation than animals foraging in familiar environments. In contrast, Bailey et al. (1988) reported that cattle grazing in familiar environments were able to associate food availabilities with specific locations on pasture, remembering where they foraged for up to 8 h using working memory. Furthermore, Bailey et al. (1989) suggested cattle can store reference memories for locations that have attractive foraging characteristics for at least 24 h.

Spatial memory refers to integration of both reference memory and working memory. Working memory is the ability of a grazing animal to remember where they have foraged for periods of up to 8 h, whereas reference memory refers to an animal's ability to recall locations that allowed for favorable eating experiences for up to 24 h (Bailey et al., 1989). Laca (1995) reported spatial memory increased foraging efficiency in grazing cattle. Large herbivores exercised reference memory to identify favorable locations and food availability for at least 20 d (Laca, 1995) and recalled specific locations with depleted resources for up to 8 h using working memory (Bailey et al., 1996).

Senft et al. (1987) reported that decisions on where to forage were separate from dietary decisions about the frequency of foraging. Bailey and Rittenhouse (1989) suggested foraging decisions are based on forage quality, forage quantity, and the concentration of certain secondary compounds in forage. They also noted that range sites with high-quality forage are likely to experience a greater rate of biomass removal than range sites with low-quality forage. Selective foraging on these sites can have a profound influence on plant community structure and function (Pieper, 1994; Jones, 2000; Launchbaugh and Howery, 2005). Grazing animals return to nutrient rich areas more often than less-productive areas of pastures (Bailey et al., 1989) and match consumption rate to availability of preferred forage species (Senft et al., 1987).

Slope and distance to water are primary drivers of grazing distribution and act as constraints under which forage quality and quantity are secondary (Bailey et al., 1996). Combining the constraints of slope and distance from water with behavioral responses elicited by forage quantity and quality can allow prediction of grazing distribution patterns (Senft, 1989; Bailey et al., 1996). Bailey et al. (1996) developed a foraging hierarchy to aid in understanding

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the decisions which grazing animals make during foraging. Six spatial scales were identified in the foraging hierarchy: bite, feeding station, patch, feeding site, camp, and home range. Grazing animals made decisions on which feeding sites, camps, and home ranges to occupy based on information collected from lower-level spatial scales (i.e., bites, feeding stations, and patches). At larger scales, such as camp and home range, grazing animals associated natural and man-made visual cues with locations of low- or high-quality forages (Howery et al., 2000). Associating visual cues with forage availability facilitated decision-making on where to graze and allowed animals to more efficiently graze in heterogeneous environments.

The Dynamics of Diet Selection

Diet selection is a function of previous eating experiences, physiological state, and available forage resources (Heady, 1964; Provenza, 1995). Grazing cattle prefer diets of varied composition (Rutter et al., 1997; Prache et al., 2000; Villalba et al., 2004). By the same token, the diet selection process is dynamic because of continual changes in animal and plant characteristics (Wallace et al., 1972; Volesky et al., 2007). Palatability is a key component in selection of one forage plant over another (Vallentine, 1990) and palatability characteristics change as plants mature (Holechek et al., 2001). Cattle may alter preferences and diet composition as some plant species enter dormancy while other plant species are actively growing (Wyffels et al., 2009). Grazing animals form preferences for palatable foods. The sensation of palatability is, in turn, affected by the post-ingestive consequences of consuming particular foods (Villalba and Provenza, 2009). Dumont and Gordon (2003) suggested that grazing animals will initially select forages that meet nutrient quality requirements before adjusting their behaviors (such as grazing time) to maintain nutrient quantity requirements.

Effects of Age on Diet Selection

Young grazing animals are constrained uniquely by the range environment. Young animals are at a disadvantage to older, more experienced grazers because they have greater nutritional requirements and lack foraging experience. Success of a grazing animal (i.e., growth, health, fecundity, or longevity) is dependent on adaptability to changing pasture conditions; therefore, less experienced (i.e., younger) cattle are thought to be more sensitive to negative changes in the foraging environment than cattle that are older and relatively more experienced

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(Leaver, 1970; Ferrer-Cazcarra and Petit, 1995). Provenza and Malechek (1986) compared diet selection and foraging time between adult and juvenile goats. They reported that adult and juvenile goats consumed similar diets; however, the juvenile goats spent more time foraging. They concluded that similar diet composition was the result of availability of forage, as well as behavior inheritance and learning by the juvenile goats in response to the presence of adult goats. The increase in foraging time by the juvenile goats was judged to result from a lack of skill in harvesting forage and more time spent seeking relatively rare but highly-palatable forage plants.

Experiences early in life cause herbivores to develop preferences or aversions to plants; these experiences affect dietary habits during adulthood (Provenza and Balph, 1987, 1988). Villalba and Provenza (2009) indicated that nutritional status of grazing herbivores and their capability to persist in range-based production systems was a function of cumulative experience as a grazer. Experienced grazers were less influenced by social models such as mother-to-offspring or peer-to-peer experiences in diet choices than younger, inexperienced animals (Provenza and Balph, 1988). In heterogeneous environments, young cattle grazing with their mothers were imprinted with foraging habits that allowed them to regulate intake of potentially-toxic or nutritious foods (Velázquez-Martínez et al., 2010). The absence of mothers as social models early in life required social (i.e., peer-to-peer) learning to increase diet selection in unfamiliar or heterogeneous environments (Provenza et al., 1992; Rutter, 2006).

Livestock previously exposed to particular forages ingest them more willingly than naïve animals (Provenza and Balph, 1988). Bailey et al. (2010) suggested naïve animals foraged less efficiently than experienced animals in a particular environment. Velázquez-Martínez et al. (2010) compared grazing behavior and diet selection of naïve heifers maintained by themselves with naïve heifers maintained with experienced heifers. They found social learning promoted the consumption of specific forages in highly-diverse tropical pastures. Furthermore, Howery et al. (1998) indicated that social learning served to introduce young animals to adaptive behaviors that are important to foraging success.

Ferrer-Cazcarra and Petit (1995) reported that younger cattle were more selective grazers than older cattle. The younger cattle had smaller bite weights which required them to graze for longer periods of time to achieve satiety. They also displayed stronger preferences for the aerial portions of plants compared to older cattle. Dunn et al. (1988) evaluated the effects of cow age and ambient air temperatures on winter grazing activity. They reported that younger cows spent

more time grazing and traveled further from fixed reference points compared to older cows. In contrast, Adams et al. (1986) reported older cows spent more time grazing compared to younger cows during winter.

Effects of age on diet selection may be dependent on the quality and quantity of available forage (Grings et al., 2001). Grings et al. (1995) evaluated the quality of diets selected by suckling calves and mature steers. Suckling calves selected a higher-quality diet than mature steers early in the growing season, possibly due to selection of different plant species or selection of different plant parts. Differences in diet quality between suckling calves and mature steers disappeared late in the growing season. Authors suggested that this may have been related to learning by calves over time, changes in forage quality, increased forage intake by calves over time, or diminished opportunity to select diets of higher relative quality as forage plants matured.

Effects of Physiological Status on Diet Selection

Lactating animals have greater energy requirements than non-lactating animals. Rook et al. (2004) reported that grazing animals with lower maintenance requirements (i.e., dry cows) had reduced metabolic rates that may lead to less selective foraging behavior. Despite differences in energy requirement, Parsons et al. (1994) reported no differences in diet selection preferences between lactating ewes and non-lactating ewes. Conversely, Penning et al. (1995) reported lactating ewes spent more time eating and had greater intake rates than non-lactating ewes.

Gibb et al. (1999) reported that lactating cows had greater forage intakes and grazed for longer periods of time than dry cows. More time spent grazing translated to fewer rumination bouts and less time spent idling by lactating cows, as well. These authors concluded that lactating cows had greater daily forage intakes than dry cows, resulting primarily from extending grazing time at the expense of rumination time. Farruggia et al. (2006) observed the effects of physiological state of grazing beef cows on diet selection. The authors reported that lactating beef cows selected a greater proportion of bites from green patches of the pasture than did dry cows. The lactating cows also tended to spend more time grazing each day than dry cows.

Microhistological Analysis

The botanical composition of grazing-herbivore diets has been evaluated by direct observation of bite counts, analysis of dead or sacrificed animal stomach contents, analysis of

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fecal material, and analysis of ruminal or esophageal extrusa collected from fistulated animals (Holechek at el., 1982). Analyses of plant fragments in ruminal or esophageal extrusa is regarded widely as the method least prone to estimation error; however, microhistological analysis of fecal material has become the most widely used method for quantifying the botanical composition of herbivore diets (Holechek, 1982). The microhistological technique was first described by Baumgartner and Martin in 1939. Sparks and Malechek (1968) verified the accuracy of the microhistological technique and reported a 1:1 ratio between relative density of plant fragments in fecal material and actual dry weight percentages. Conversely, Holechek and Valdez (1985a; 1985b) reported the 1:1 relationship was not consistent for all forages. Factors that affected the accuracy of the microhistological technique included: digestibility differences between plants (Stewart, 1970; Slater and Jones, 1971; Vavra et al., 1978; McInnis et al., 1983), woody materials present in the diet (Holechek and Valdez, 1985a; 1985b), observer errors (Holechek et al., 1982), calculation procedures used to estimate diet botanical composition (Holechek and Gross, 1982), and sample-preparation techniques (Vavra and Holechek, 1980; Holechek et al., 1982).

The primary weakness of microhistological analyses of fecal material for estimating botanical composition of cattle diets is that it may over-estimate consumption of grasses and shrubs and underestimate consumption of forbs compared with microhistological analyses of ruminal contents. In addition, some plant species may be unidentifiable in fecal material (Slater and Jones, 1971). The primary strengths of fecal microhistology are that it is non-invasive, it does not disrupt normal grazing behavior, and sample collection is not constrained by the availability of fistulated animals (Soder et al., 2009).

Holechek and Vavra (1981) determined that 5 slides per sample and 20 randomly-selected fields per slide were needed to adequately measure the frequency with which plant fragments appeared in the fecal material of grazing livestock. Bontti and Bóo (2002) suggested observing a minimum of 14 animals per treatment to accurately estimate the botanical composition of a grazing animal's diet using microhistological analysis of fecal material; however, the number of animals needed per treatment to detect a 2% difference in selection was reported to vary with plant species from 3 to 12 animals per treatment (Eckerle et al., 2009).

Alipayo et al. (1992) reported that the accuracy of microhistological analysis of fecal material from diets of cattle, sheep, and goats fed mixtures of grasses, forbs, and shrubs was

within acceptable ranges. Bennett et al. (1999) reported fecal botanical composition was useful in determining diet composition of grazing steers. Furthermore, fecal analysis was useful also for estimating botanical composition of deer diets (Anthony and Smith, 1974) and prairie dog diets (Wydeven and Dahlgren, 1982).

Burning

Prescribed burning is used to improve the average quality of pasture forage by removing old growth and making new plant growth more accessible to grazing cattle. Burning tallgrass-prairie rangelands stimulates growth of native prairie plants, allows for manipulation of plant species composition (Towne an Owensby, 1984), and helps control invasive shrub species (Gibson and Hulbert, 1987). McMurphy and Anderson (1965) reported that the advantages of late-spring burning compared to not burning pastures on the Kansas Flint Hills were an increase in the relative proportion of *Andropogon gerardii*, control of invasive plant species, and greater cattle weight gains. Furthermore, Svejcar (1989) reported spring burning of tallgrass prairie in central Oklahoma increased favorable plant species and decreased undesirable forbs. Towne and Owensby (1984) demonstrated that negative shifts in plant composition occurred over time on unburned native-tallgrass prairie pastures. In addition, complete fire exclusion resulted in more random distribution of forbs and a decrease in landscape diversity (Biondini et al., 1989).

Summary

Understanding the fundamental principles that govern decision-making by grazing animals is an essential part of rangeland and livestock management. Implementing management practices such as strategic supplement placement can motivate grazing animals to utilize less-desirable areas of a pasture. Understanding how animal age and physiological state affect botanical composition of herbivore diets can allow available forage resources to be matched with animal type. Recognizing the importance of these factors will assist in the development of sustainable grazing practices on native rangelands.

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Chapter 2 - **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 Hills**

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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 dry, granular form (GRANULAR) or mineral provided in a low-protein, cooked, molasses-based block (BLOCK); both were fed *ad libitum*. The GRANULAR supplement was supplied to cattle via a covered mineral feeder; BLOCK was supplied via an open-topped barrel. Both GRANULAR and BLOCK 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 BLOCK was greater than GRANULAR during each data-collection period in study 1; however, relative differences in consumption diminished (treatment × time, $P = 0.03$) over time. In study 2, BLOCK consumption was greater than GRANULAR in periods 1, 6, and 7 but was not different (treatment × time, $P < 0.01$) from GRANULAR during periods 2, 3, 4, and 5. Increased consumption of BLOCK in study 1 translated to greater frequency of herd visits to supplement-deployment sites compared to GRANULAR (2.82 vs. 2.47 herd visits/d; $P = 0.02$) and longer herd visits to supplement-deployment sites compared to GRANULAR (125.7 vs. 54.9 min/herd visit; $P < 0.01$). The frequency of herd visits to mineral feeding sites in study 2 were similar ($P > 0.10$) between treatments for periods 1 through 6; however, herds visited BLOCK more often than GRANULAR during period 7 ($P < 0.01$). Herd visits to BLOCK were longer than those to GRANULAR 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 BLOCK influenced the location of grazing cattle more strongly than GRANULAR 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

Introduction

Uneven grazing distribution can result in localized over- and under-grazing 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 effects can be minimized by preventing localized over-grazing (Pieper, 1994; Jones, 2000; Launchbaugh and Howery, 2005).

Water development, cross-fencing, and herding can reduce the impact of localized over-grazing and improve the overall uniformity of forage use in individual pastures (Skovlin, 1957; Cook, 1966; Kauffman 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 under-used and away from over-used 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 high relative palatability compared to those with moderate palatability (Bailey and Welling, 2002). Little research has directly compared the effects of mineral supplements with differing palatability 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 palatability 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 (protocol # 2650). 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, KS (average size = 123 ± 5 ha; 39.2310º N, 96.6698º 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, non-lactating beef cows (n = 240; average initial BW = 562 ± 38 kg) were stratified by body weight 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, KS (average size = 89 ± 31 ha; 38.9987º N, 96.5495º 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 body weight and parity and assigned randomly to pastures (n = 30-70 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 typical of the Kansas Flint Hills, in order of abundance, 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 (GRANULAR) or mineral delivered in a low-protein, cooked, molasses-based block (BLOCK; Table 2.1); both were fed to cattle *ad libitum*. Supplements were formulated to contain similar amounts and availabilities of macro- and trace minerals; however, GRANULAR was based on NaCl (19%) and BLOCK contained no NaCl. The GRANULAR supplement was supplied to cattle via a covered mineral feeder (0.75 m diameter); BLOCK was supplied via an open-topped barrel provided by the manufacturer (57 kg; 0.75 m diameter). Both GRANULAR and BLOCK were deployed in each pasture, allowing animals within individual pastures the opportunity to display a preference for one supplement type over the other.

No additional NaCl was supplied to cattle in our study even though manufacturers of low-protein, molasses-based mineral carriers commonly recommend that such products be co-located on pasture with salt. The major objective of our study was to make a 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 GRANULAR or BLOCK. Within pasture, matched supplement-deployment sites were a minimum of 250 m from one another.

Grazing-exclusion cages (1.5 m diameter) were set up at each 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 m^2).

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 2.2). 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 2.2).

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 d 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 approximately 2 m above ground and trained on supplement feeders. The field of view of the cameras was approximately 30° at a focal length of 9 m. 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) or nighttime visits (1800 to 0600). 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 assure *ad libitum* availability. Total consumption of GRANULAR and BLOCK was determined gravimetrically on d 1 and d 14 of each data-collection period. Disappearance of supplement was considered equivalent to consumption.

Supplement consumption, frequency and duration of herd visits to mineral deployment sites, and forage disappearance were analyzed using a mixed model (SAS Inst. Inc., Cary NC). Paired supplement-deployment sites within pasture were the experimental unit. The model included fixed effects for treatment, period, and treatment × period and random effects for pasture and pasture × treatment. When F-tests were significant ($P \leq 0.05$), means were separated using the method of Least Significant Difference. Treatment and treatment × period differences were discussed when $P < 0.05$; trends were discussed when $P > 0.05$ and ≤ 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 2.2). Based on these figures, we concluded forage availability did not limit DMI of cows at the stocking rates used in our study.

Consumption of BLOCK was greater than GRANULAR during each data-collection period in study 1 (Figure 2.1); 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 consumption of BLOCK and GRANULAR during study 1 was 0.19 and 0.06 kg·cow^{-1}·d^{-1}, respectively. In study 2, intake of BLOCK was greater than GRANULAR during data-collection

periods ending in early June, mid-September, and late September; however, voluntary intake of BLOCK and GRANULAR was not different (treatment × period, $P < 0.01$) during data-collection periods ending in late June, July, and August (Figure 2.2). 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 BLOCK and GRANULAR during study 2 was 0.20 and 0.13 kg·cow^{-1}·d^{-1}, respectively. Average consumption of GRANULAR 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 BLOCK in study 2 was similar to that observed during study 1 (0.20 vs. 0.19 kg·cow^{-1}·d^{-1}, respectively). Intake of BLOCK in our study was similar to that reported by Bailey and Welling (1999) and Bailey et al. (2008); however, it should be noted that % 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 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 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, regardless of whether they were designed to deliver protein or minerals, were more attractive to grazing beef cows than conventional, dry mineral supplements.

Due to the nature of the molasses-based carrier, BLOCK contained small amounts of protein (i.e., 4%) and crude fat (i.e., 3%), whereas GRANULAR did not (Table 2.1). 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 $g \cdot cow^{-1} \cdot d^{-1}$, respectively). We interpreted this information to suggest that more research is needed to determine whether low levels 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 wished 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 fact. We assumed that each animal's appetite 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; Bailey and Welling, 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 to when salt alone was available. Bryant (1982) suggested cattle use salt when it is convenient, but do not alter their grazing patterns to obtain it. Consequently, there may be little or no synergy for altering grazing distribution when co-locating salt and a molasses-based mineral carrier.

The greater consumption of BLOCK in study 1 was associated with more frequent ($P =$ 0.02; Figure 2.3) herd visits to sites where BLOCK was deployed compared to sites where GRANULAR was deployed. Additionally, herd visits to BLOCK sites were longer (P < 0.01; figure 2.4) than those to GRANULAR 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 to 0600) to BLOCK in study 1 was similar ($P = 0.16$) to that for GRANULAR (15.7 vs. 12.2 h / d, respectively; data not shown).

During study 2, the frequency of herd visits to BLOCK and GRANULAR sites was similar during data collection periods conducted from June through mid-September; however, herds visited BLOCK nearly twice as often as GRANULAR during late September (treatment x period interaction, $P < 0.01$; Figure 2.5).

Overall, it appeared that herds visited BLOCK 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 to periods of relatively good forage quality.

Herd visits to BLOCK sites in study 2 were longer than those to GRANULAR sites ($P < 0.01$; Figure 2.6). The average duration of herd visits to GRANULAR was numerically similar during studies 1 and 2 (54.9 vs. 51.4 min / herd visit, respectively); however, the duration of herd visits to BLOCK appeared to be numerically longer during study 1 compared to study 2 (125.7 vs. 83.8 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 to winter. Conversely, time spent around granular mineral supplements appeared to be consistent between summer and winter.

The total length of nighttime visits (1800 to 0600) to BLOCK in study 2 was greater ($P < 0.01$) than that for GRANULAR (13.4 vs. 11.3 h / d, respectively; data not shown). More time spent in the vicinity of BLOCK compared with GRANULAR 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 forage availability within 100 m of supplement-deployment sites was not influenced by treatment during study 1 ($P = 0.54$; Figure 2.7) or study 2 ($P = 0.81$; Figure 2.8). Under the conditions of forage-availability measurement, more frequent and longer herd visits to BLOCK sites did not appear to negatively impact herbage availability compared with GRANULAR. 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.

Implications

We concluded that BLOCK supplements influenced the activities of grazing cows more strongly than GRANULAR supplements 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. 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 pasture during the winter, spring, and early fall.

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Table 2.1 Guaranteed minimum composition of dry, salt-based, granular mineral supplement and low-moisture, cooked, molasses-based mineral supplement supplied to grazing beef cows during study 1 and grazing beef cows and calves during study 2

	Mineral Delivery System[a]	
Item	Dry granular mineral [b]	Molasses-based mineral [c]
CP, %	-	4
Crude fat, %	-	3
Ca, %	8	8
P, %	8	8
Na, %	19	-
Cu, ppm	1000	1000
Co, ppm	12	12
I, ppm	50	50
Mn, ppm	4000	4000
Se, ppm	18	18
Zn, ppm	4000	4000

[a] Supplied by manufacturers
[b] Custom Blend - Farmer's Cooperative, Inc., Onaga, KS
[c] New Generation Feeds, Belle Fourche, SD

Table 2.2 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

Harvest Month	Forage Availability, kg DM/ha	DM, %	OM, %	CP, % DM	NDF, % DM	ADF, % DM
Study 1						
March	2,763 ± 443	94.8	88.9	5.3	76.0	44.6
April	2,357 ± 379	80.8	86.8	5.4	72.5	43.2
May	2,242 ± 584	53.9	88.0	8.3	62.7	43.4
Study 2						
June	2,631 ± 534	48.2	89.1	10.8	79.7	43.9
July	3,571 ± 653	79.7	90.9	8.0	78.0	43.1
August	3,786 ± 824	94.6	90.9	6.3	63.9	41.5
September	2,990 ± 738	94.8	90.2	6.8	64.6	43.4

Figure 2.1 Effect of mineral-supplement delivery system and advancing season on intake of mineral supplements by beef cows during study 1 (treatment x period interaction; $P =$ 0.03). Error bars represent the SE of the least-squares means
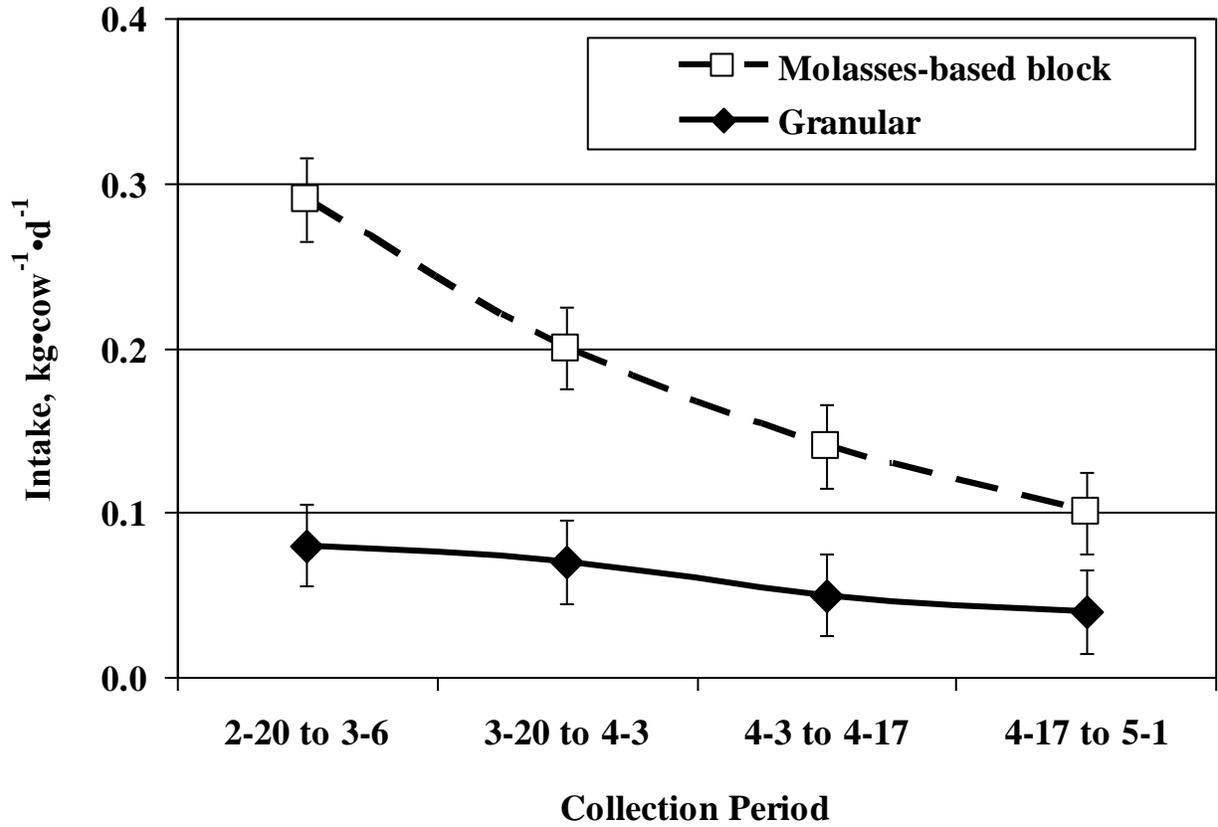
Figure 2.2 Effect of mineral-supplement delivery system and advancing season on intake of mineral supplements by beef cows and calves during study 2 (treatment x period interaction; $P < 0.01$). Error bars represent the SE of the least-squares means
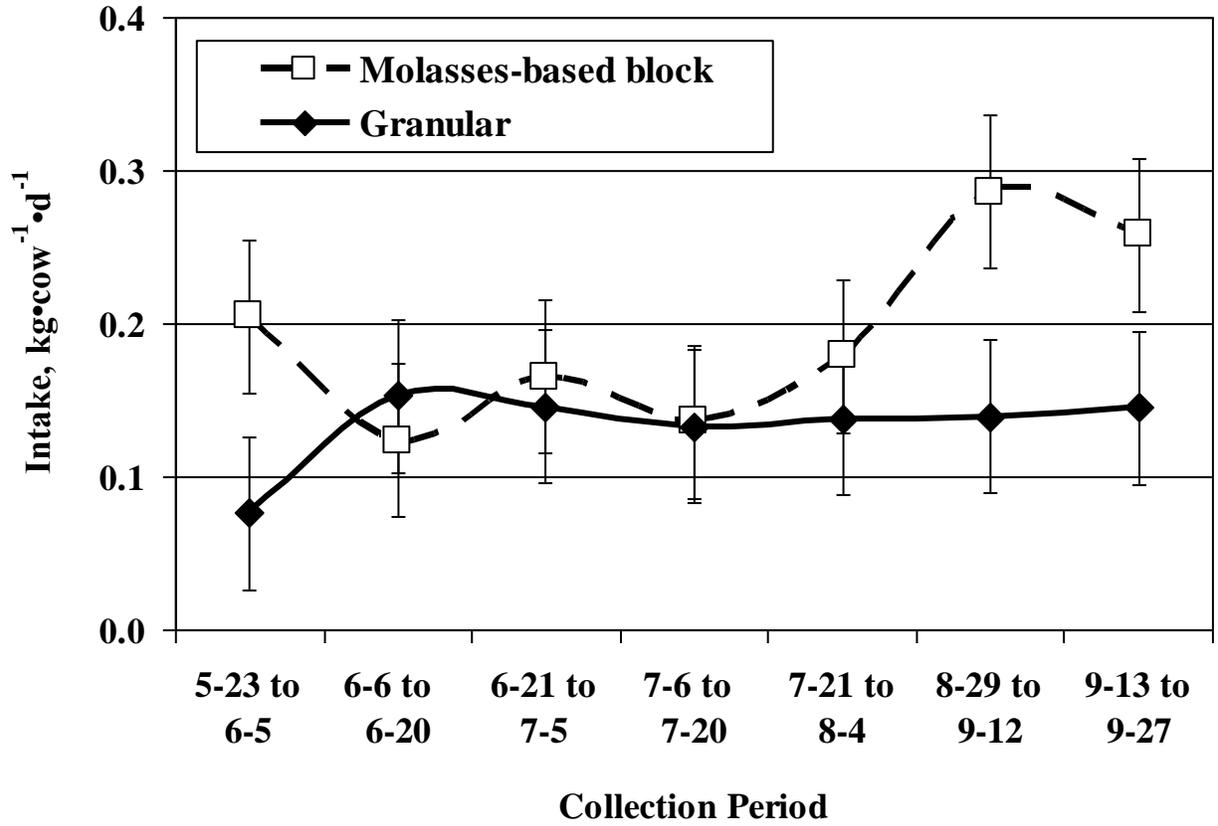
Figure 2.3 Effect of mineral-supplement delivery system on the average frequency with which beef-cow herds visited supplement-deployment sites during study 1 (main effect of treatment; _P_ = 0.02). Error bars represent the SE of the least-squares means

Figure 2.4 Effect of mineral-supplement delivery system on the average duration of beef-cow herd visits to supplement-deployment sites during study 1 (main effect of treatment; *P* < 0.01). Error bars represent the SE of the least-squares means
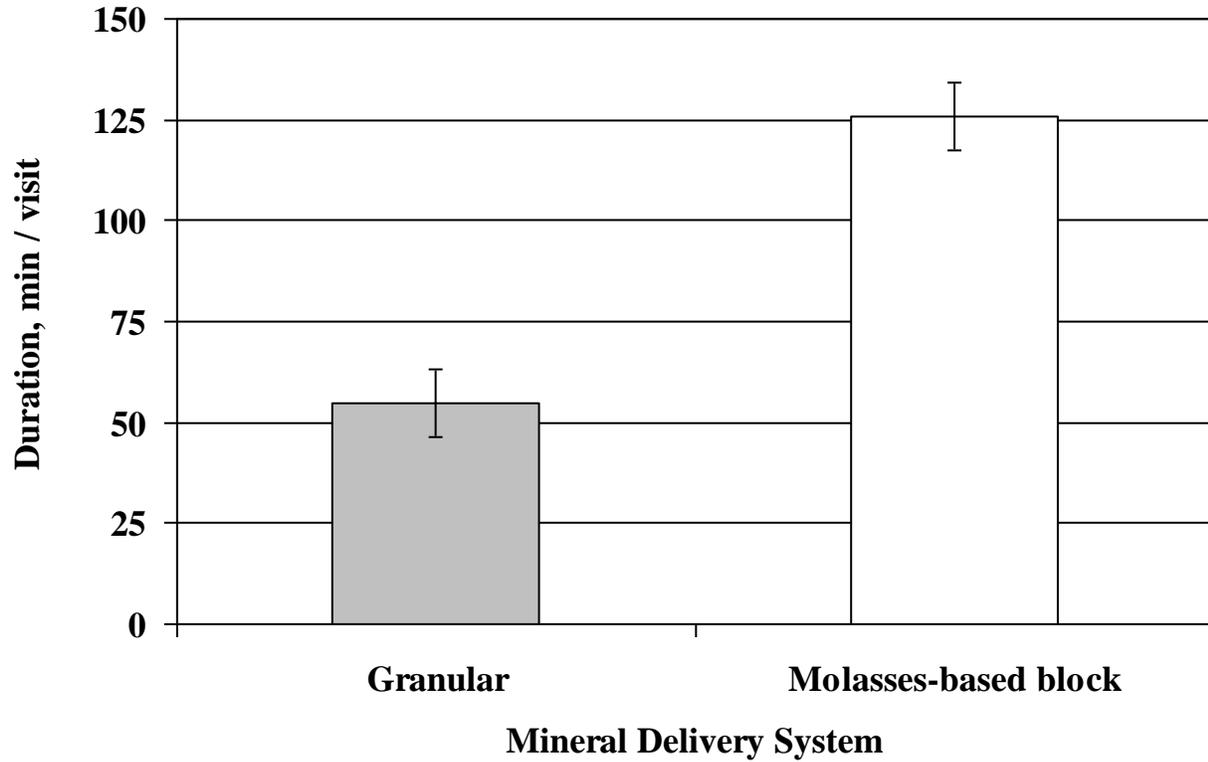
Figure 2.5 Effect of mineral-supplement delivery system and advancing season on the frequency with which beef-cow herds visited supplement-deployment sites during study 2 (treatment x period interaction; *P* < 0.01). Error bars represent the SE of the least-squares means
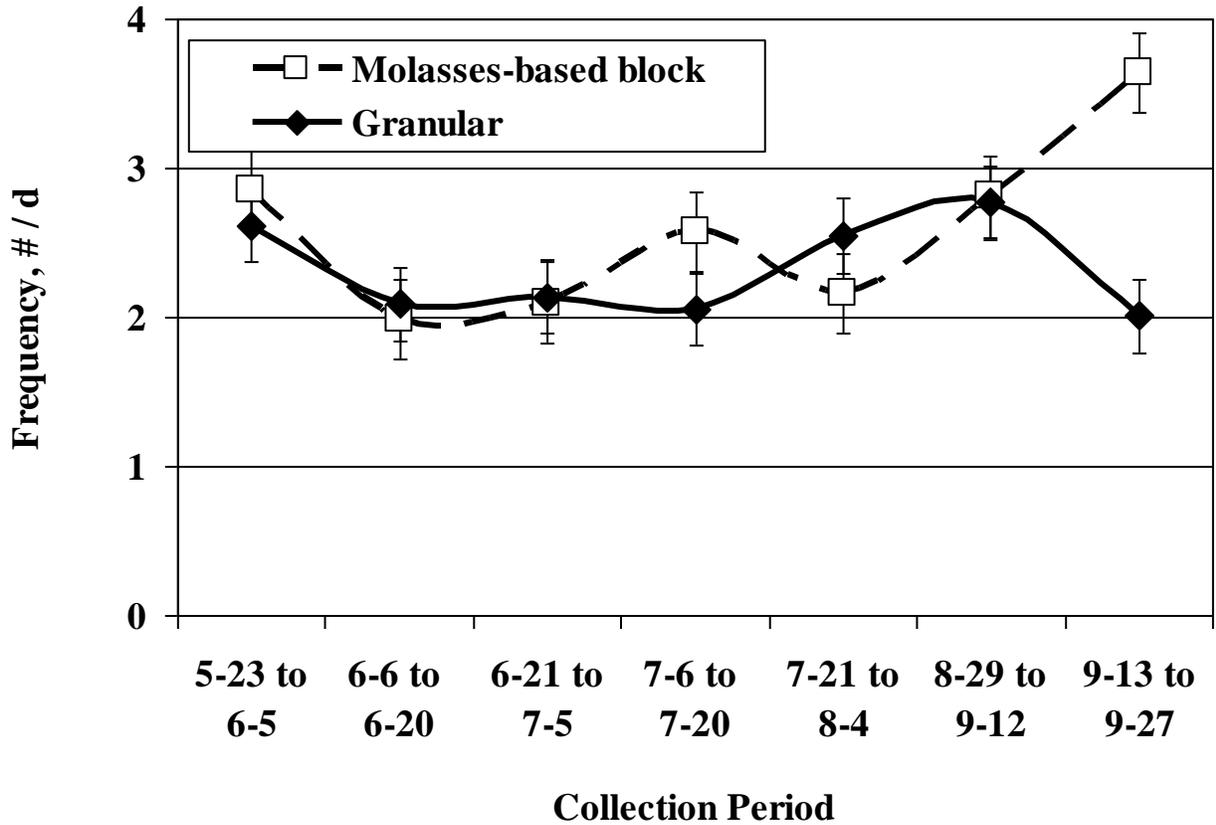
Figure 2.6 Effect of mineral-supplement delivery system on the average duration of beef-cow herd visits to supplement-deployment sites during study 2 (main effect of treatment; *P* < 0.01). Error bars represent the SE of the least-squares means
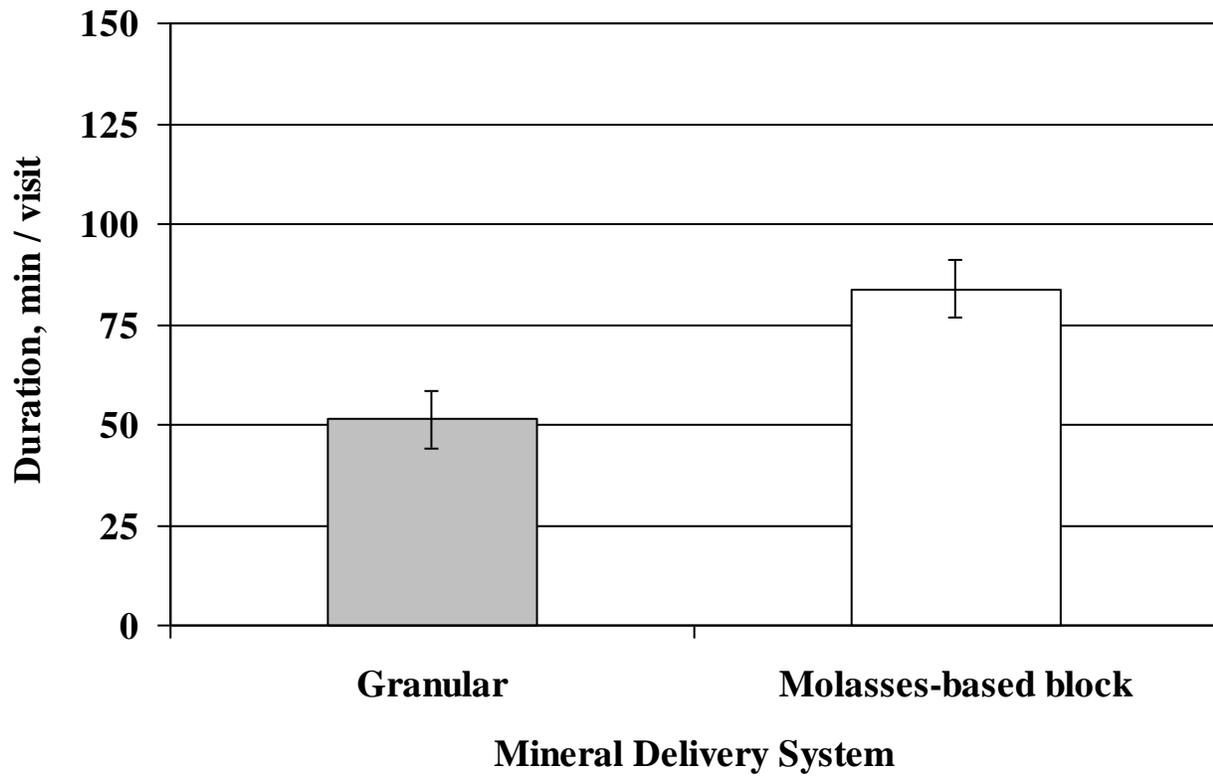
Figure 2.7 Effect of mineral-supplement delivery system on average forage disappearance from within a 100-m radius of supplement-deployment sites during study 1 (main effect of treatment; *P* = 0.44). Error bars represent the SE of the least-squares means
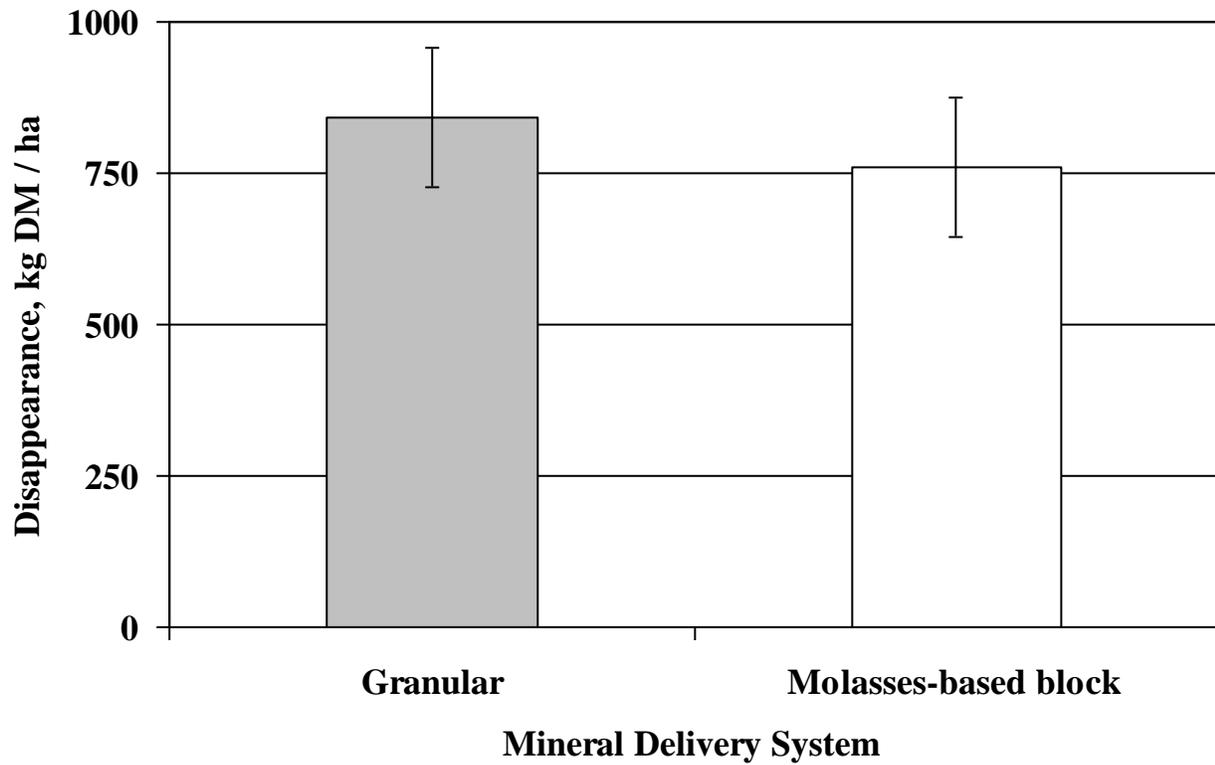
Figure 2.8 Effect of mineral-supplement delivery system on average forage disappearance from within a 100-m radius of supplement-deployment sites during study 2 (main effect of treatment; P = 0.81). Error bars represent the SE of the least-squares means
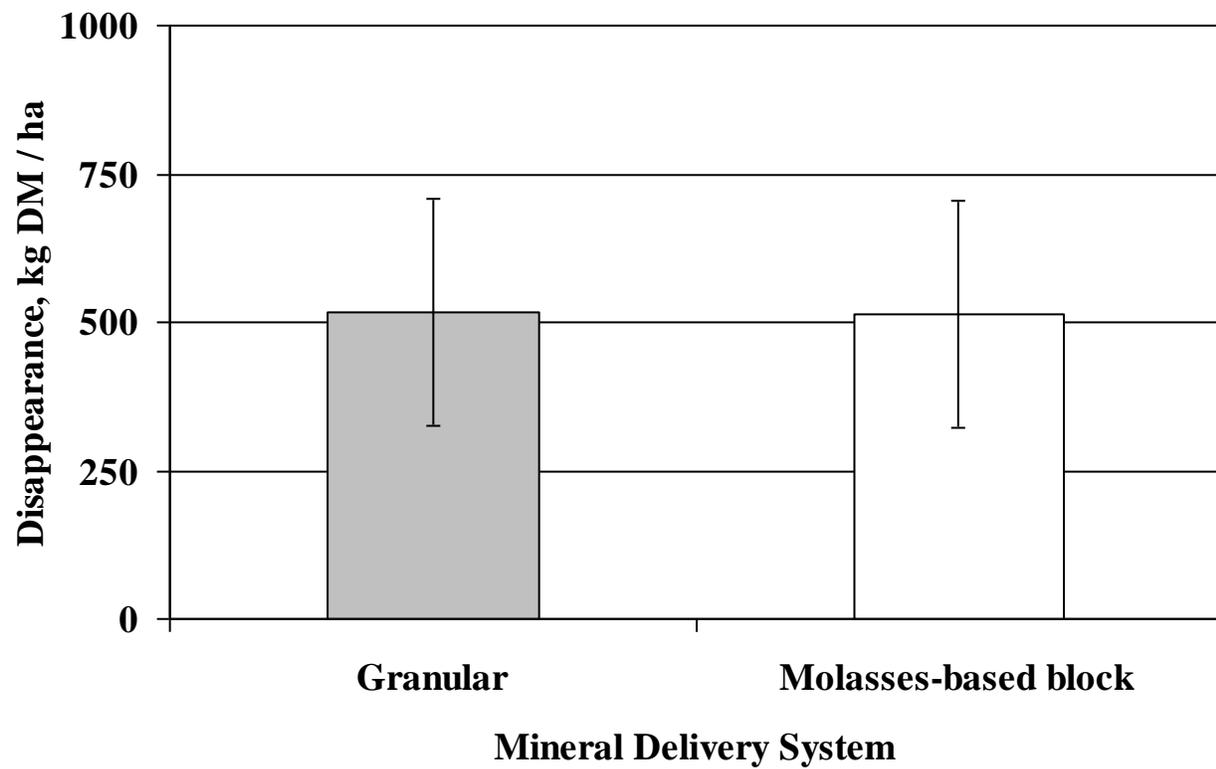
Chapter 3 - **Forage Selection Preferences by Experienced, Multiparous and Naïve, Primiparous Beef Cows Grazing Native Tallgrass Range during Winter**

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Abstract

Our objective was to evaluate diet selection preferences of 18 experienced, multiparous and 20 naïve, primiparous beef cows (9 and 1 yr old, respectively) grazing dormant, native tallgrass pastures during winter. The study was analyzed as a 4-period, 8-pasture (average size = 28 ha) Latin rectangle. Predominant pasture forage species were *Andropogon geradii* and *Schizachyrium scoparium*, which were grouped together for analysis (BL); *Bouteloua curtipendula* (SO); *Bouteloua gracilis*, (BG); *Panicum virgatum* (SG); *Sorghastrum nutans* (IG); *Amorpha canescens* (LP); *Symphyotrichum ericoides* (HA); *Liatris punctata* (DG); and *Dalea purpurea* (PP). Animals were grouped randomly by parity status (n = 4 or 5) and grazed 1 of 4 assigned pastures during 4 consecutive 48-h periods. Fecal samples were collected from each animal at the end of each period. Range-plant fragments in fecal samples were quantified using a modified microhistological technique; plant fragment prevalence in fecal material was assumed to be equivalent to diet composition on a DM basis. Naïve, primiparous cows selected more forbs and fewer grasses (main effect of parity; $P = 0.09$) than experienced, multiparous cows. Experienced, multiparous cows ate more ($P = 0.07$) BL and less ($P = 0.05$) DG than naïve, primiparous cows. Consumption of all forbs, PP, LP, and DG by both classes of cows declined ($P \leq 0.04$) over time, while consumption of all grasses, BL, and BG increased ($P \leq 0.02$) over time, indicating that forb availability may have diminished during the study. Occasional differences in consumption of IG, SG, SO, and HA between primiparous and multiparous cows occurred; however, differences were inconsistent (parity $\times$ period effect; $P \leq 0.02$) over time. Differences in diet selection patterns between experienced, multiparous and naïve, primiparous cows during a short-term winter grazing period could be indicative of differences in long-term foraging strategies. We interpreted these data to suggest that foraging strategies associated with cow longevity may be related to selection preferences during periods of poor forage quality.

Key Words: beef cows, beef heifers, botanical composition, grazing

Introduction

Estimating the nutritive value of a grazing animal's diet is a significant challenge. Description of the botantical composition of a grazed diet is vital in that regard (Holechek et al., 1982a). Microhistological analysis of fecal material has been used for estimating the botanical composition of wild and domestic ungulate diets since first described by Baumgartner and Martin in 1939 (Holechek and Vavra, 1981; Holechek et al., 1982b; Alipayo et al., 1992). The primary weakness of microhistological analyses of fecal material for estimating botanical composition of cattle diets is that it may over-estimate consumption of grasses and shrubs and underestimate consumption of forbs compared with microhistological analyses of ruminal contents. The primary strengths of fecal microhistology are that it is non-invasive and it does not disrupt animal grazing behavior. In addition, sample collection is not constrained by the availability of fistulated animals (Soder et al., 2009). Little research has been conducted on the diet selection preferences of experienced, multiparous beef cows compared to naïve, primiparous beef cows. Nutritional status of grazing herbivores and their capability to persist in range-based production systems (i.e., longevity) may be a function of cumulative experience as a grazer (Villalba and Provenza, 2009). When forage quality is poor, differences in the capability of animals to alter nutrient intake by selectively grazing specific forage species may be magnified. Therefore, we speculated that foraging strategies learned through extensive experience (e.g., mature, multiparous cows) may contrast with foraging strategies formed through limited experience (e.g., naïve, primiparous cows). To that end, our objective was to characterize differences in diet selection between experienced, multiparous and naïve, primiparous beef cows grazing dormant, native tallgrass pastures during winter.

Materials and Methods

All procedures used in the care and handling of animals in our study were approved by the Kansas State University Institutional Animal Care and Use Committee (Protocol # 2650).

Design and Treatments

The study was analyzed as a 4-period, 8-pasture (average size = 28 ha) Latin rectangle. Multiparous cows (n = 18; average initial BW = 589 ± 50 kg; average initial body condition score = 4.9 ± 0.5) were all 9 y of age and had grazed dormant, native tallgrass pastures during

each winter of their lives. Primiparous cows (n = 20; average initial BW = 301 ± 25 kg; average initial body condition score = 4.1 ± 0.4) were all 12 mo of age and had never grazed dormant, native tallgrass pastures. Grazing experience of primiparous cows was limited only to the period in which they suckled their dams as calves (0 to 6 mo of age), during the summer months (May to October). Cows were grouped randomly into grazing cohorts by parity status (n = 4 or 5); cohorts were then assigned randomly to graze 4 pastures in sequence during 4 consecutive 48-h periods, according to the protocol described by Lyons and Stuth (1992). Cows were allowed to adapt to their cohort groupings and to graze dormant, native tallgrass pastures located adjacent to the study area for 9 d before the experiment began. No supplemental feed or mineral was offered to cows during the study.

The study was conducted at the Kansas State University Beef Stocker Unit, located approximately 5 km north of Manhattan, KS. Soils and vegetation on this site have been described previously (Anderson and Fly, 1955; Launchbaugh and Owensby, 1978; Towne and Owensby, 1984; Owensby et al., 1988; Olson and Cochran, 1998). Predominant pasture forage species at this location were big bluestem (*Andropogon geradii*) and little bluestem (*Schizachyrium scoparium*), which were grouped together for the purposes of microhistological analysis; sideoats grama (*Bouteloua curtipendula*); blue grama (*Bouteloua gracilis*); switchgrass (*Panicum virgatum*); indiangrass (*Sorghastrum nutans)*; leadplant (*Amorpha canescens*); heath aster (*Symphyotrichum ericoides*); dotted gayfeather (*Liatris punctata*); and purple prairie clover (*Dalea purpurea*). Average chemical composition of the pasture forage during the study was 93.5% DM, 2.98% CP, 71.6% NDF, and 50.8% ADF.

Collections

Individual grazing cohorts were gathered into a corral at the end of each 48-h collection period. Fecal grab samples were collected from each animal. Each grab sample was hand mixed to ensure homogeneity and a 40-g subsample was retained for analysis.

Sample Preparation

Microhistological sample preparation methods were described by Holechek (1982), as modified by Eckerle et al. (2009). Samples were soaked overnight in 50% EtOH (v/v). The EtOH was removed and samples were homogenized and washed with de-ionized H_2O through a No. 200 US-standard sieve to remove contaminants. Samples were then re-homogenized,

strained, and dried at 55°C for 96 h. Dried samples were ground (#4 Wiley Mill, Thomas Scientific, Swedesboro, NJ, USA) to pass a 1-mm screen and stored for slide preparation (Bennett et al., 1999).

Slide Preparation

Slide preparation methods were described by Eckerle et al. (2009). Subsamples (0.5 g) of dried, ground plant material were soaked in de-ionized H_2O for 1 h to soften them. Approximately 20 mL of NaOH (0.05M) was then added to each sample. Samples were incubated for 20 min at room temperature to destroy plant pigments. Samples were rinsed with de-ionized H_2O over a No. 200 US-standard sieve to remove NaOH and then homogenized in a blender with 20 mL of de-ionized H_2O for 1 min. Samples were then rinsed a second time over a No. 200 US-standard sieve.

Samples were placed on a slide, $1 - 3$ drops of Hertwig's solution was applied, and the slide was placed over a propane flame until dry. One to 2 drops of Hoyer's solution was added to mount a cover slip. Slides were dried for 96 h in a 55°C-oven before viewing.

Slides were viewed on a compound microscope at $10 \times$ magnification. The microscope was equipped with a digital camera; each slide field was photographed for comparison with standard slides (Eckerle et al., 2009). Twenty fields per slide were selected randomly from the entire slide view and were used to measure the frequency with which plant fragments appeared (Holechek and Vavra, 1981). Plant fragment prevalence in slide fields was assumed to be equivalent to prevalence in fecal samples and equivalent to % botanical composition of the diets grazed by beef cows (Sparks and Malechek, 1968). Plant fragments that were not among the 10 predominant range plants for which standards were prepared were classified as either an unknown grass or an unknown forb.

Statistics

Data were analyzed as a Latin rectangle using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Class variables included parity, grazing cohort, animal, period, and pasture. The model included terms for parity, period, and parity $\times$ period. Period $\times$ pasture $\times$ cohort within parity was used as the error term. Type-3 error rates were used to test for differences between

treatments and periods. Means were separated using the method of Least Significant Difference and were reported with pooled standard errors. Means were considered different when $P < 0.10$.

Results and Discussion

The objective of our study was to characterize differences in diet selection between experienced, multiparous and naïve, primiparous beef cows grazing dormant, native tallgrass pastures during a short-term winter grazing bout. Villalba and Provenza (2009) indicated that nutritional status of grazing herbivores and their capability to persist in a range-based production system (i.e., longevity) was a function of cumulative experience as a grazer. We speculated that, under conditions of poor forage quality, differences in the capability of animals to alter nutrient intake by selectively grazing specific forage species would be magnified. Furthermore, we speculated that foraging strategies learned through extensive experience (e.g., mature, multiparous cows that had grazed dormant, native-tallgrass pastures each winter of their lives) may contrast with foraging strategies formed through limited experience (e.g., naïve, primiparous cows that had never grazed dormant, native-tallgrass pastures).

Relatively few plant species comprise the majority of diets selected by beef cows grazing the Kansas Flint Hills during winter (Eckerle et al., 2009). The prevalence of unidentifiable grasses and forbs in each period × grazing cohort observation was ≤ 0.14% in our study; moreover, there were no effects ($P \geq 0.32$) of treatment or period on the amount of unidentified grasses or forbs in beef cow diets (Table 3.1).

Naïve, primiparous cows selected more ($P = 0.09$) forbs and fewer ($P = 0.09$) grasses than experience, multiparous cows (Table 3.2). The average magnitude of the difference was modest (i.e., 4.03%) but typical of previous reports comparing botanical composition of diets grazed by different classes of beef cattle (Grings et al., 2001; Clark et al., 2009). In addition, experienced, multiparous cows ate more ($P = 0.07$) big + little bluestem and less ($P = 0.05$) dotted gayfeather than naïve, primiparous cows (Table 3.2). Grass consumption by the cows in our study was less and forb consumption greater than that reported for spring and summer grazing seasons in the northern US (Grings et al., 2001; Clark et al., 2009; Wyffels et al., 2009). Celaya et al. (2007) reported also that beef cattle demonstrate strong preferences for grasses. Conversely, Mohammad et al. (1996) and Eckerle et al. (2009) reported similar grass:forb in cattle diets in the central and southern US.

Greater consumption of forbs by primiparous cows compared with multiparous cows was unexpected. Soder et al. (2009) indicated that preference for broadleaf plants generally increases with grazing experience; however, these conclusions were based on research with greater-quality forages than those evaluated in our study. The post-ingestive consequences of consuming dry, dormant broadleaf plants may be different from those associated with consumption of actively-growing broadleaf plants.

Extensive vegetation surveys of our study site reported that forbs comprised only 2.5 to 6.6% of all range plants and 4 to 18% of total herbage production (Towne and Owensby, 1984). Forb consumption in our study ranged from a high of 39.62% in period 1 to a low of 27.05% in period 4 (Table 3.3). Consumption of all forbs, purple prairie clover, leadplant, and dotted gayfeather by both classes of cows declined ($P \leq 0.04$) over time, while consumption of all grasses increased ($P \leq 0.01$) over time (Table 3.3). During period 1, consumption of big bluestem + little bluestem and blue grama was at its greatest, with differences in consumption inconsistent ($P \leq 0.02$) over periods 2, 3, and 4 (Table 3.3). Cows appeared to actively seek certain forb species during foraging. Similar observations were reported by Mohammad et al. (1996). The pastures in our study were subject to repeated grazing bouts over an 8-d period. The decline in forb consumption over time may be interpreted to indicate that forb availability diminished over the course of the study.

Success of a grazing animal may be defined as sustained productivity or persistence in range-based production systems. Success depends on foraging conditions (i.e., forage quantity, forage quality, and animal adaptability). Young or inexperienced cattle are thought to be more sensitive to foraging conditions than experienced cattle (Leaver, 1970; Ferrer-Cazcarra and Petit, 1995). Provenza and Balph (1988) indicated that livestock grazed familiar forages more readily than unfamiliar forages. Villalba and Provenza (2009) postulated that nutritional status of grazing herbivores and their longevity in range-based production systems was a function of adaptability. Experiences during any grazing bout may cause herbivores to adopt particular behaviors or to develop preferences or aversions to particular plants; these may affect foraging habits later in life (Provenza and Balph, 1987; 1988).

Occasional differences in consumption of indiangrass, switchgrass, sideoats grama, and heath aster between primiparous and multiparous cows occurred; however, differences were inconsistent (parity × period effect; $P \leq 0.02$) over time (Table 3.1). The significance of these

differences was judged to be relatively minor. When offered unlimited grazing, herbivores consumed a mixed diet expressing occasional but unsustained preferences for certain forage plants (Parsons et al., 1994; Hester et al., 1999; Rutter et al., 2004; Soder et al., 2007).

Implications

Differences that we observed in diet selection patterns between experienced, multiparous and naïve, primiparous cows during a short-term winter grazing period could be indicative of differences in long-term foraging strategies. We interpreted these data to suggest that foraging strategies associated with cow longevity may be related to selection preferences during periods of poor forage quality. Further research in this area appears warranted.

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Table 3.1 Effects of collection period on botanical composition of diets selected by experienced, multiparous or naïve, primiparous beef cows grazing the Kansas Flint Hills during winter

| | | | | | | | *P*-Values | |
Item	Period 1	Period 2	Period 3	Period 4	SEM	Parity	Period	Parity × Period
Total grasses, %								
Multiparous	61.74	66.51	73.02	74.55	2.532	0.09	< 0.01	0.55
Primiparous	59.02	64.59	64.75	71.35				
Big bluestem + little bluestem, %								
Multiparous	27.24	15.20	19.62	17.77	1.491	0.07	< 0.01	0.58
Primiparous	26.39	10.54	17.02	15.99				
Indiangrass, %								
Multiparous	19.44	34.17	37.23	40.89	1.728	0.24	< 0.01	< 0.01
Primiparous	16.38	44.74	36.23	41.79				
Switchgrass, %								
Multiparous	9.97	11.78	11.59	10.05	1.145	0.01	0.60	0.03
Primiparous	9.34	5.09	7.01	7.54				
Blue grama, %								
Multiparous	3.57	3.91	2.60	4.30	0.508	0.79	0.02	0.13
Primiparous	4.62	2.90	2.79	3.64				
Sideoats grama, %								
Multiparous	1.47	1.64	1.84	1.57	0.244	0.82	0.22	0.04
Primiparous	2.23	1.06	1.48	1.60				
Unknown Grasses, %								
Multiparous	0.03	0.05	0.03	0.02	0.055	0.32	0.74	0.60
Primiparous	0.04	0.09	0.10	0.14				
Total forbs, %								
Multiparous	38.26	33.48	26.97	25.44	2.532	0.09	< 0.01	0.55
Primiparous	40.98	35.41	35.25	28.65				
Purple prairie clover, %								
Multiparous	14.23	13.66	11.70	9.99	1.117	0.15	< 0.01	0.22
Primiparous	15.93	16.22	10.10	12.06				
Leadplant, %								
Multiparous	10.83	10.32	5.58	6.16	1.559	0.42	0.04	0.14
Primiparous	10.62	9.05	10.60	7.39				
Dotted gayfeather, %								
Multiparous	7.06	6.48	6.17	5.35	1.051	0.04	0.01	0.28
Primiparous	11.24	8.44	7.77	5.63				
Heath aster, %								
Multiparous	6.15	3.00	3.71	3.87	0.858	0.88	< 0.01	< 0.01
Primiparous	3.18	1.98	6.89	4.18				
Unknown Forbs, %								
Multiparous	0.03	trace	0.01	0.01	0.014	0.58	0.60	0.38
Primiparous	trace	trace	trace	0.02				

Table 3.2 Effect of parity status on botanical composition of diets selected by beef cows grazing the Kansas Flint Hills during winter

Item	Primiparous	Multiparous	SEM	*P*-Value
Total grasses, %	64.93	68.96	1.404	0.09
Big bluestem + little bluestem , %	17.49	19.96	0.791	0.07
Total forbs, %	35.07	31.04	1.404	0.09
Dotted gayfeather, %	8.26	6.26	0.579	0.05

Table 3.3 Effect of collection period on botanical composition of diets selected by beef cows grazing the Kansas Flint Hills during winter

Item	Period 1	Period 2	Period 3	Period 4	SEM	*P*-Value
Total grasses, %	60.38	65.55	68.89	72.95	1.779	< 0.01
Big bluestem + little bluestem, %	26.82	12.87	18.32	16.88	1.040	< 0.01
Blue grama, %	4.10	3.41	2.70	3.97	0.350	0.02
Total forbs, %	39.62	34.45	31.11	27.05	1.779	< 0.01
Purple prairie clover, %	15.08	14.94	10.90	11.02	0.775	< 0.01
Leadplant, %	10.72	9.68	8.09	6.77	1.093	0.04
Dotted gayfeather, %	9.15	7.46	6.97	5.49	0.737	0.01

Chapter 4 - **Botanical Composition of Diets Grazed by Mature, Lactating Cows with Calves and Mature, Non-Lactating Cows Maintained on either Burned or Unburned Native Tallgrass Prairie**

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Abstract

Our objective was to compare diet selection preferences of 32 mature, lactating beef cows (**L**; initial BW = 566 ± 55.9 kg) suckling calves with 32 mature, non-pregnant, non-lactating beef cows (**NL**; initial BW = 551 ± 53.2 kg) grazing burned or unburned native tallgrass prairie during summer. Our study was conducted on 8 pastures (97 ± 39.9 ha); 4 were burned in mid-April and 4 had no recent burning history. Grazing commenced May 15. Predominant forage species were *Andropogon geradii*, *Schizachyrium scoparium*, *Bouteloua curtipendula* (SO), *Bouteloua gracilis* (BG), *Panicum virgatum* (SG), *Sorghastrum nutans* (IG), *Amorpha canescens* (LP), *Symphyotrichum ericoides* (HA), *Liatris punctata* (DG), and *Dalea purpurea* (PP). Four L and 4 NL cows were grouped randomly and assigned to graze a single burned or unburned pasture for 120 d. Fecal samples were collected from each animal on d 30, 60, 90, and 120 of the grazing period. Range-plant fragments in fecal samples were quantified using a modified microhistological technique; plant fragment prevalence in fecal material was assumed to equal % botanical composition of the diet. Selection of IG decreased ($P < 0.01$) over time while selection of SG, BG, LP, and HA increased ($P < 0.01$) over time. Cows selected more SG, LP, and PP ($P < 0.03$) in unburned pastures than in burned pastures. Conversely, cows selected more ($P < 0.01$) SO in burned pastures than in unburned pastures. Total graminoid selection was greater ($P < 0.01$; 74.2%) on burned than unburned pastures (71.8%). In contrast, selection of forbs was greater ($P < 0.01$; 28.2%) on unburned than burned pastures (25.8%). Cows tended to select more (burn × period; $P < 0.09$) SG and LP in unburned pastures over time and selected more (burn × period; $P < 0.01$) SO in burned pastures over time. There were no differences ($P > 0.05$) in diet selection patterns between **L** and **NL** cows. Under the conditions of our study, botanical composition of beef cow diets was influenced by spring burning of native tallgrass pastures but was not influenced by lactation and pregnancy status.

Key Words: beef cows, botanical composition, diet selection, grazing

Introduction

The diet selection process is dynamic because of changes in animal and plant characteristics (Wallace et al., 1972; Volesky et al., 2007). Lactating animals have greater energy requirements than non-lactating animals. Farruggia et al. (2006) reported lactating beef cows grazed more selectively than non-lactating dry cows and suggested greater selectivity was the result of the animal searching to fulfill specific nutrient needs to support lactation. Lactating ewes (Penning et al., 1995) and lactating dairy cows (Gibb et al., 1999) grazed for longer periods of time and had greater intakes than their non-lactating counterparts. Conversely, Parsons et al. (1994) reported no differences in diet selection between lactating and non-lactating ewes.

Microhistological analysis of fecal material is a widely used method for quantifying the botanical composition of a grazing animal's diet since first described by Baumgartner and Martin in 1939 (Holechek, 1982; Alipayo et al., 1992). Little research has been conducted on how diet selection preferences of lactating beef cows with suckling calves and non-lactating beef cows are influenced by prescribed burning. Prescribed spring burning of native rangelands is used to improve the average quality of pasture forage by removing old growth and making new plant growth more accessible to grazing cattle. Our objective was to characterize differences in diet selection between lactating beef cows suckling calves and non-pregnant, non-lactating beef cows grazing either burned or unburned native tallgrass prairie during summer.

Materials and Methods

All procedures used in the care and handling of animals in our study were approved by the Kansas State University Institutional Animal Care and Use Committee (Protocol # 2650). Our study was conducted at the Kansas State University Commercial Cow-Calf Unit located approximately 5 km northwest of Manhattan, KS. Soils and vegetation on this site have been described previously (Anderson and Fly, 1955; Launchbaugh and Owensby, 1978; Towne and Owensby, 1984; Owensby et al., 1988; Olson and Cochran, 1998). Predominant pasture forage species at this location were big bluestem (*Andropogon geradii*), little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), blue grama (*Bouteloua gracilis*), switchgrass (*Panicum virgatum*), indiangrass (*Sorghastrum nutans*), leadplant (*Amorpha canescens*), heath aster (*Symphyotrichum ericoides*), dotted gayfeather (*Liatris punctata*), and

purple prairie clover (*Dalea purpurea*). Average chemical composition of the pasture forage during the study is shown in Table 4.1 on a month-by-month basis.

We compared botanical composition of diets selected by 32 mature, pregnant, lactating beef cows suckling calves (**L**; initial BW = 566 ± 55.9 kg) with 32 mature, non-pregnant, non-lactating beef cows (**NL**; initial BW = 551 ± 53.2 kg). Our study was conducted on 8 native tallgrass pastures (97 ± 39.9 ha); 4 were burned in mid-April and 4 had no recent burning history. Grazing commenced May 15. Four L and 4 NL cows were grouped randomly and assigned to graze a single burned or unburned pasture for 120 d. The L and NL cows were allowed to comingle within pastures and remained in their assigned pasture throughout the study. Water, salt, and a granular, salt-based mineral supplement (17% NaCl, 16% Ca, 8% P, 0.2% Mg, 3,300 ppm Zn, 1,200 ppm Cu, and 0.22 ppm Se) were available to cattle continually.

Cows were gathered into a corral and fecal grab samples were collected from each animal on d 30, 60, 90, and 120 of the grazing period. Each grab sample was hand-mixed to ensure homogeneity and a 40-g subsample was retained for analysis.

Preparation of samples for microhistological analysis was conducted as described by Eckerle et al. (2009). Wet fecal samples were soaked overnight in 50% EtOH (v/v). After soaking, samples, EtOH was decanted and samples were homogenized and washed with de-ionized H_2O through a No. 200 US-standard sieve to remove contaminants. Samples were then re-homogenized, strained, and dried at 55°C for 96 h. Dried samples were ground (#4 Wiley Mill, Thomas Scientific, Swedesboro, NJ, USA) to pass a 1-mm screen and stored for slide preparation (Bennett et al., 1999).

Slide preparation methods were described by Eckerle et al. (2009). Subsamples (0.5 g) of dried, ground, and washed fecal material were soaked in de-ionized H_2O for 1 h to soften them. Approximately 20 mL of NaOH (0.05M) was then added to each sample. Samples were incubated for 20 min at room temperature to destroy plant pigments. Samples were subsequently rinsed with de-ionized H_2O over a No. 200 US-standard sieve to remove NaOH and then homogenized in a blender with 20 mL of de-ionized H_2O for 1 min. Samples were rinsed a second time over a No. 200 US-standard sieve.

Samples were placed on slides using an eyedropper, 1 to 3 drops of Hertwig's solution was applied, and the slide was placed over a propane flame until dry. One to 2 drops of Hoyer's

solution was added to mount a cover slip. Slides were dried for 96 h in a 55°C oven before viewing.

Slides were viewed on a compound microscope at $10 \times$ magnification. The microscope was equipped with a digital camera; each slide field was photographed for comparison with standard slides (Eckerle et al., 2009). Twenty fields per slide were selected randomly from the entire slide view and were used to measure the frequency with which plant fragments appeared (Holechek and Vavra, 1981). Individual plant species were identified according to their histological characteristics. Big bluestem and little bluestem were grouped together for the purposes of analysis because of histological similarities.

Plant fragment prevalence in slide fields was assumed to be equivalent to prevalence in fecal samples and equivalent to % botanical composition of the diets grazed by beef cows (Sparks and Malechek, 1968). Plant fragments that were not among the 10 predominant range plants for which standards were prepared were classified as either an unknown grass or an unknown forb; however, these were present in trace amounts only and were not reported.

Data were analyzed as a mixed-model, completely randomized design with a split-split plot using the GLIMMIX procedure of SAS (SAS Inst. Inc., Cary, NC). Class variables included burn regime, pasture, treatment, animal, and period. The MODEL statement included terms for: burn regime, treatment, treatment $\times$ burn regime, period, period $\times$ burn regime, treatment $\times$ period, and treatment $\times$ period $\times$ burn regime. The RANDOM statement included terms for: pasture within burn; treatment $\times$ pasture within burn; animal within burn, pasture, and treatment; period $\times$ pasture within burn; period $\times$ treatment $\times$ pasture within burn; and period $\times$ animal within burn, pasture, and treatment. Type-3 F-tests were used to test for differences for all fixed effects. Main effects of treatment and period were reported when treatment $\times$ period effects ($P \geq$ 0.10) were not detected. Means were separated using the method of Least Significant Difference and were reported with pooled standard errors. Means were considered different when $P < 0.10$.

Results and Discussion

The objective of our study was to characterize differences in diet selection between mature, pregnant, lactating beef cows with suckling calves and mature non-pregnant, non-lactating beef cows grazing either burned or unburned native tallgrass prairie during summer. We speculated that during the summer grazing season, lactating cows with calves and non-lactating

cows would display distinctive preferences for certain species. Furthermore, we anticipated that these diet selection preferences might be influenced by prescribed burning.

There were no treatment differences ($P \geq 0.11$) in the botanical diet composition between lactating and non-lactating cows (Table 4.2). Similar findings were reported by Parsons et al. (1994) who found no differences in diet composition between lactating ewes and non-lactating ewes. Conversely, Farruggia et al. (2006) reported lactating cows grazed more selectively than non-lactating, non-pregnant cows. Rook et al. (2004) suggested that lesser maintenance requirements could result in less selective foraging behaviors by non-lactating compared to lactating ruminants.

Cows consumed more ($P = 0.01$; 74.2 vs. 71.8%, respectively) grasses and fewer ($P = 0.01$; 25.8 vs. 28.2%, respectively) forbs on burned pastures compared to unburned pastures (Table 4.3). McGinty et al. (1983) reported greater selection of forbs on unburned pastures compared to burned pastures because forb availability was reduced by burning. Cows ate more ($P < 0.01$) sideoats grama and less ($P \leq 0.02$) switchgrass, leadplant, and purple prairie clover on burned pastures than on unburned pastures. Prescribed burning is widely practiced in the Kansas Flint Hills to remove standing dead plant material, to remove litter, to improve weight gains of stocker cattle, to manipulate plant species composition, and to eradicate invasive woody plants (Launchbaugh and Owensby, 1978; Towne and Owensby, 1984; Gibson and Hulbert, 1987).

As the grazing season progressed, selection of switchgrass increased (burn × period effect, $P = 0.09$) sharply in both burned and unburned pastures, whereas selection of sideoats grama generally decreased (burn × period effect, $P < 0.01$; Table 4.4). Selection of leadplant doubled (burn × period effect, $P = 0.04$) on burned pastures month-by-month but selection was inconsistent in unburned pastures. Selection of dotted gayfeather ranged from 12.3 to 20.4% of the diet in June, July, and August and diminished to 8.5 to 8.9% in September (burn × period effect, $P = 0.05$).

Cows selected more ($P < 0.01$) switchgrass, blue grama, leadplant, and heath aster over time, whereas they selected less ($P < 0.01$) indiangrass over time (Table 4.5). Palatability is a major factor driving selection preferences by grazing herbivores (Vallentine, 1990) and is reduced as plants approach reproductive maturity and dormancy (Holechek et al., 2001). Under unrestricted grazing conditions, herbivore preference for specific forage plants is known to change over time (Parsons et al., 1994; Hester et al., 1999; Rutter et al., 2004; Soder et al., 2007).

The cows used in our study may have modified their diets over time to select greater proportions of plants that were slower to reach maturity. Alternatively, decreased consumption over time may have been related to diminishing availability or regrowth of certain forage plants.

Consumption of all grasses and all forbs changed slightly ($P < 0.01$, Table 4.5) from month to month during the grazing season; however, the relative proportions of grasses and forbs remained consistently within the range of 71 to 75% grasses and 25 to 29% forbs.

Implications

The botanical composition of diets grazed by beef cows during summer in the Kansas Flint Hills was influenced by prescribed spring burning but was not influenced by lactation status. We interpreted these data to suggest that forage selection preferences of beef cows can be altered with spring burning of native tallgrass pastures. Further research in this area appears warranted.

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Table 4.1 Average chemical composition of native tallgrass-prairie forage grazed by beef cows and calves during summer

Item	June 15	July 15	August 15	September 15
DM %	92.8	92.6	93.3	93.9
OM %	8.5	9.5	8.4	8.8
CP, %DM	10.2	7.9	5.3	4.3
NDF, %DM	61.5	63.3	68.8	69.7
ADF, % DM	40.0	40.8	44.2	44.9

Table 4.2 Effect of collection period on botanical composition of diets (%) selected by lactating cows with calves or non-lactating, non-pregnant cows grazing the Kansas Flint Hills during summer

| | | | | | | | *P*-Values | |
Item	June 15	July 15	August 15	September 15	SEM	Trt	Period	Trt × Period
Total grasses, %								
Lactating	74.1	70.8	72.3	72.7	1.03	0.18	< 0.01	0.45
Non-lactating	76.7	71.3	73.6	72.4				
Big bluestem + little bluestem, %								
Lactating	6.1	12.9	13.9	10.9	1.15	0.37	< 0.01	0.15
Non-lactating	8.2	11.9	13.2	11.8				
Indiangrass, %								
Lactating	50.4	37.7	35.2	29.4	1.36	0.12	< 0.01	0.60
Non-lactating	51.6	37.6	38.3	31.3				
Switchgrass, %								
Lactating	4.2	4.4	7.5	10.4	0.76	0.88	< 0.01	0.41
Non-lactating	3.7	5.0	7.1	10.8				
Blue grama, %								
Lactating	1.8	2.3	5.4	14.9	0.51	0.83	< 0.01	0.16
Non-lactating	2.5	2.5	4.5	10.8				
Sideoats grama, %								
Lactating	8.6	11.7	8.6	4.7	0.69	0.94	< 0.01	0.20
Non-lactating	7.5	11.9	8.6	5.5				
Total forbs, %								
Lactating	25.9	29.2	27.7	27.3	1.03	0.18	< 0.01	0.45
Non-lactating	23.3	28.7	26.4	27.6				
Purple prairie clover, %								
Lactating	7.4	6.9	6.9	7.9	0.80	0.92	0.25	0.88
Non-lactating	7.5	6.5	6.9	8.5				
Leadplant, %								
Lactating	0.6	0.8	1.7	3.4	0.43	0.25	< 0.01	0.41
Non-lactating	0.9	0.9	1.5	4.0				
Dotted gayfeather, %								
Lactating	15.5	19.8	15.9	8.8	1.02	0.11	< 0.01	0.35
Non-lactating	12.7	19.5	15.1	8.6				
Heath aster, %								
Lactating	0.6	0.9	2.5	6.2	0.69	0.63	< 0.01	0.07
Non-lactating	1.0	0.9	2.1	5.2				

Table 4.3 Main effects of pasture burning regime on botanical composition of diets selected by beef cows grazing the Kansas Flint Hills during summer

Item	Burned	Unburned	SEM	*P*-Value
Total grasses, %	74.2	71.8	0.52	0.01
Switchgrass, %	5.3	7.2	0.27	< 0.01
Sideoats grama, %	9.0	7.1	0.26	< 0.01
Total forbs, %	25.8	28.2	0.52	0.01
Leadplant, %	1.1	1.7	0.12	< 0.01
Purple prairie clover, %	6.4	8.3	0.50	0.02

Table 4.4 Burn regime × collection period effects on botanical composition of diets selected by beef cows grazing the Kansas Flint Hills during summer

Item	June 15	July 15	August 15	September 15	SEM	P-Value
Switchgrass, %						
Burned	2.9	4.2	6.3	9.9	0.80	0.09
Unburned	5.2	5.3	8.5	11.4		
Sideoats grama, %						
Burned	10.1	13.8	8.9	5.2	0.78	< 0.01
Unburned	6.4	10.0	8.4	5.0		
Leadplant, %						
Burned	0.4	0.8	1.5	3.2	0.37	0.04
Unburned	1.2	0.9	1.7	4.2		
Dotted gayfeather, %						
Burned	16.0	18.9	15.8	8.9	1.04	0.05
Unburned	12.3	20.4	15.2	8.5		

Table 4.5 Main effect of collection period on botanical composition of diets selected by beef cows grazing the Kansas Flint Hills during summer

Item	June 15	July 15	August 15	September 15	SEM	*P*-Value
Total grasses, %	75.5	71.1	73.0	72.5	0.71	< 0.01
Indiangrass, %	51.0	37.7	36.7	30.3	0.97	< 0.01
Switchgrass, %	3.9	4.7	7.3	10.6	0.51	< 0.01
Blue grama, %	2.1	2.4	5.0	12.7	1.23	< 0.01
Total forbs, %	24.5	28.9	27.0	27.5	0.70	< 0.01
Leadplant, %	0.7	0.8	1.6	3.7	0.30	< 0.01
Heath aster, %	0.8	0.9	2.3	5.7	0.61	< 0.01

Chapter 5 - **Effects of Round Bale Feeding Method on Hay Dry Matter Intake and Eating Behavior by Beef Cows Maintained on Dormant Winter Pastures**

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Abstract

The effects of large, round hay bale feeding method on DMI of smooth bromegrass hay (7.9% CP; 67% NDF) and eating behavior by beef cows maintained on dormant winter pastures were evaluated. Angus × cows (n = 150; average initial BW = 530 ± 54 kg) with calves were assigned randomly to 1 of 3 native tallgrass pastures. Three bale-feeding systems were evaluated in consecutive 3 × 3 Latin squares: bales fed in a ring feeder (**FEEDER**), bales unrolled on the ground (**UNROLL**), and bales chopped with a flail-type hay processor and deposited on the ground (20-cm particle length; **PROCESSED**). Treatment sequence and cow-calf pairs were assigned randomly to pastures (n = 50 cow-calf pairs/pasture). One round bale (average weight = 522 ± 31 kg) was fed per 24-h period on a centrally-located feeding area in each pasture that was covered with a polyethylene tarp (9 x 15 m) and monitored with a motion-sensitive camera. Residual hay was gathered and placed into tared containers at the end of each 24-h intake-measurement period. The weight of the residual hay was recorded for each treatment. Bale strings were removed and weighed to the nearest g from unprocessed bales prior to feeding but were left on the bales that were chopped prior to feeding. Immediately after processed bales were fed, the string wrapped around the flail tube of the hay processor was completely removed and weighed. There were no differences ($P \geq 0.45$) in total hay DMI per pasture, hay DMI/cow/d, or hay DMI/cow/h between treatments. The amount of uneaten hay was similar ($P = 0.28$) between treatments also. The frequency and duration of herd visits to bale feeding sites in each pasture were similar ($P > 0.19$) between treatments. The amount of binding string removed from unprocessed bales prior to feeding was not different ($P = 0.87$) from the amount recovered from the flail tube of the hay processor after feeding processed bales. Hay intake, hay refusal, frequency of use, and duration of use were not influenced by hay feeding method when large, round bales were offered to cows and calves grazing dormant native pasture. String used to bind large, round bales of hay may be largely recovered on the flail tube of flail-type hay processors, obviating the need for removal of string prior to feeding.

Key words: beef cows, hay, intake

Introduction

Annual purchased and raised feed costs are the largest single contributor to variation in profitability among cow-calf enterprises; moreover, harvested forages usually represent a significant portion of those costs (Miller et al., 2001). Harvested forages are often fed in the central United States during winter and early spring months to supplement the diets of beef cows grazing dormant native pastures. Most harvested forage is packaged, stored, and fed in the form of large, round bales (Buskirk et al., 2003), which increase labor efficiency and ease of handling relative to small, square bales (Pyatt and Berger, 2003). Depending on storage method, storage losses of large round bales can range from 2 to 20% of DM (Belyea et al., 1985; Baxter et al., 1986; Huhnke, 1993; Shinners et al., 2009). In addition to storage losses, feeding losses of large round bales are reported to range from 12 to 25% of DM (Belyea et al., 1985). Minimizing wastage by using alternative methods to feed large round bales may reduce feed costs and increase efficiency of use by beef cows. While voluntary DMI by ruminants is influenced by forage composition and digestibility (Van Soest, 1965; Robles et al., 1981), chopping harvested forages to decrease particle size can increase passage rate (Ehle, 1984; Firkins et al., 1986) and may stimulate DMI. Frequency of visits to hay-feeding sites and aggressive social interactions between beef cows near hay-feeding sites also may influence hay intake (Buskirk et al., 2003).

Removing bale string prior to feeding large round bales is widely practiced to prevent accidental ingestion of string or entanglement and subsequent injury to livestock. Removal of bale string is time-consuming; moreover, large quantities are difficult to store or discard. Grinding hay bales without removing string may result in string particle size being reduced to a level that is less hazardous to livestock or in the string being retained in the hay-grinding device.

The objectives of our study were: 1) to measure intake, refused hay, frequency of use, and duration of use of large, round hay bales by cows and calves maintained on dormant, native pastures when bales were offered either in processed form, in unrolled form, or in intact form in a bale feeder and 2) to quantify how much of the string used to bind large, round hay bales was recovered from the flail tube of a flail-type hay processor vs. that which was expelled into the hay offered to cattle. We hypothesized that feeding processed hay to cow-calf pairs maintained on dormant native pastures would result in greater short-term hay DMI and less refused hay compared to feeding hay in a common ring feeder or in the form of an unrolled bale. We also

hypothesized that a more rapid rate of intake would result in less frequent but longer periods of daily use for processed hay compared to hay fed in a common ring feeder or hay fed in the form of an unrolled bale. Finally, we anticipated that at least 50% of the string used to bind large, round bales would be recovered on the flail tube of a flail-type hay processor.

Materials and Methods

Kansas State University Institutional Animal Care and Use Committee approved all animal-handling and animal-care practices used in this research (Protocol # 2650). One-hundred-fifty Angus × cows (n = 150; average initial BW = 530 ± 54 kg, average initial BCS = 5.4 ± 0.3) with calves (average initial age = 18 ± 6 d) from the Kansas State University Commercial Cow-Calf Unit were used to evaluate 3 large, round bale feeding treatments, which were representative of common feeding practices for harvested forages in the central United States during winter and early spring (Landblom et al., 2006). Treatments included: 1) bales fed in a common ring feeder (**FEEDER**), 2) bales rolled out on the ground (**UNROLL**), and 3) bales chopped with a flail-type hay processor (**PROCESSED**).

Large, round hay bales (n = 72; 1.5 × 1.5 m) were selected randomly from a population of 300 bales that were harvested in June during the summer prior to the experiment from a single smooth bromegrass (*Bromus inermis*) pasture in Pottawatomie County, KS. Prior to the experiment, all bales were weighed (average weight = 522 ± 31 kg) and sampled with a 0.75 m probe. Bales were numbered and assigned randomly to treatments. Average chemical composition of the bales used during periods of intake measurement was 94 ± 0.7 % DM, 7.9 ± 1.02 % CP, 67 ± 5.1 % NDF, 40 ± 2.6 % ADF, 0.4 ± 0.06% Ca, and 0.1 ± 0.03% P. There were no differences ($P > 0.56$) in the average chemical composition of bales assigned to each treatment (data not shown).

The study was conducted on 3 native tallgrass pastures (average size = 122 ± 5 ha) located at the Kansas State University Commercial Cow-Calf Unit. Treatment sequence was assigned randomly to each of the 3 pastures using steps appropriate for a consecutive 3 × 3 Latin square design. Cows in each pasture were allowed *ad libitum* access to assigned treatments during six consecutive 96-h periods. Hay intake and eating behavior were recorded during the final 24 h of each period.

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Cows were weighed and assigned a BCS (1 to 9 scale; 1 = extremely thin, 9 = obese) by 3 experienced evaluators prior to the experiment. Cows were stratified by BW, BCS, and calving date and assigned randomly to 1 of the 3 pastures (n = 50/pasture) used for the experiment. Pastures were stocked at approximately 2.2 hectares per cow and all cows had continual access to self-fed, salt-based trace mineral and white salt before and during the experiment. No other supplements were provided during the study. Major graminoid species in pastures, in order of abundance, were big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), and switchgrass (*Panicum virgatum*). Pasture forage samples were collected at the beginning and the end of the study by clipping forage 1 cm above the ground within a randomly-placed sampling frame (0.25 m^2). Average chemical composition of pasture forage during the study was 54 ± 7.3% DM, 5.0 ± 2.4% CP, 74 ± 9.7% NDF, and 44 ± 5.3% ADF.

Treatments were deployed in each pasture on a centrally-located feeding area. All areas were well-drained and topographically similar from pasture to pasture. Each feeding area (9 × 15 m) was covered with a polyethylene tarp, fastened securely to the ground with stakes and weights, to facilitate recovery of unconsumed hay. Additionally, each feeding area was equipped with 1 motion-sensitive digital camera. Cameras (Wildview model SSTC-TGL3M) were mounted approximately 1 m above the ground and trained along the long axis of each tarped feeding site. The field of view of the cameras was approximately 30˚ at a focal length of 9 m.

The bale ring feeder used for FEEDER had a 1.2 m radius, 7.6 m circumference, total height of 1.2 m, a solid base height of 0.53 m, and semi-open access area that was 0.67 m high. The access area was separated at 36 cm intervals by 2.54 x 2.54 cm vertical steel rods, which attached the solid base to a circular upper rim. For UNROLL, bales were manually unrolled in 2 equal portions that were placed side by side on the tarped feeding area. The total area covered by unrolled bales was approximately 3 m wide and 9 m long. For PROCESSED, bales were chopped (Bale Buster model 2650, Duratech Industries, Jamestown, ND) to an approximate particle length of 20 cm and deposited on the tarped feeding area. The total area covered by chopped forage was approximately 3 m wide and 9 m long.

A bale ring feeder was placed on the center of each tarped feeding area for FEEDER, and a single bale was placed inside. A bale fed as UNROLL was placed on one end of the tarped feeding area and manually rolled out toward the opposite side. For PROCESSED, a single bale

was chopped and deposited using the flail-type hay processor into two parallel windrows on the tarped feeding area. UNROLL and PROCESSED hay was maintained at least 3 m from the outer edges of the tarp to ensure residual hay would remain on the tarp for collection at the end of each period.

Residual hay was gathered and placed into tared containers at the end of each 24-h intake-measurement period. The weight of the residual hay was recorded for each treatment. Care was taken to avoid contamination of residual hay with soil, manure, and pasture forage. A representative sample of residual hay was obtained by removing a handful of hay from 15 different positions within tared containers. These grab samples were composited within treatment and period and placed in a sealed, labeled polyethylene bag and frozen for subsequent analysis. Remaining residual hay was discarded. The tarped feeding sites in each pasture were swept and were completely free of foreign material before the next treatment was deployed.

Dry matter intake was calculated as the amount of hay delivered to each pasture less the residual hay remaining at the end of each 24-h period. Restricting time of access to large round bales reduced hay intake (Miller et al., 2007) and hay disappearance (Cunningham et al., 2003). Therefore, the length of time cows were allowed access to FEEDER, UNROLL, and PROCESSED was verified and was not different (23.9, 23.6, 23.5 h, respectively; $P = 0.18$) between treatments.

Herd visits to each tarped feeding site were defined as each time an animal or group of animals occupied the feeding area. The motion-sensitive digital cameras were programmed to record the frequency and duration of herd visits. Digital photographs were collected at 5-min intervals from the time the first animal in the herd approached the feeding area until the last animal departed. The duration of herd visits to tarped feeding sites was defined as the interval of time between when the first and last pictures were taken. A herd visit was considered complete when the interval between pictures was > 60 min. The frequency of herd visits to tarped feeding sites was considered to be the total number of herd visits per 24-h intake-measurement period. Visits to each tarped feeding site were recorded as daytime visits (0600 to 1800), nighttime visits (1800 to 0600), or visits that spanned both daytime and nighttime hours.

Immediately prior to the time bales were fed, bale strings were removed and weighed to the nearest g from each bale assigned to the FEEDER and UNROLL treatments but were left on the bales assigned to the PROCESSED treatment. Immediately after forage was chopped and

deposited for PROCESSED, the string wrapped around the flail tube of the hay processor was completely removed and weighed.

Hay and ort samples were processed by drying in a forced air-over (96 h; 50°C), weighed, and ground (#4 Wiley Mill, Thomas Scientific, Swedesboro, NJ, USA) to pass a 1-mm screen. Processed samples were analyzed for DM (16 h; 105°C) and N (FP-528, LECO, St. Josephs, Michigan). Forage NDF and ADF were analyzed using an ANKOM fiber analyzer (ANKOM technology Corp., Fairport, NY) according to standard procedures provided by the manufacturer. The NDF procedure was conducted with amylase and sulfite but without correction for residual ash. Calcium concentration of hay was measured using methods described by Bowers and Rains (1988). Phosphorus concentration of hay was analyzed as described by Fiske and Subbarrow (1925).

Dry matter intake, weight of residual hay, frequency of herd visits, and duration of herd visits were analyzed as a consecutive 3×3 Latin square design (Proc GLM; SAS Inst. Inc., Cary, NC). Pasture was the experimental unit. Models included terms for treatment, period, and pasture. The bale string data were analyzed as a completely randomized design (Proc GLM; SAS Inst. Inc., Cary, NC). The model included terms for treatment and period. Type-3 error rates were used to test fixed effects. Least Squares means were separated using the method of Least Significant Difference. Means were considered different when $P \leq 0.05$.

Results and Discussion

No treatment differences ($P \geq 0.45$) were observed for total hay intake, hay intake/cow, or hay intake/cow/h (Table 5.1). Landblom et al. (2006) reported that feeding large, round bales in a tapered-cone bale feeder reduced hay consumption, equipment cost, feeding time, and offered significant cost savings per cow compared to unrolling or processing bales. Hay waste around the tapered-cone bale feeder was 5-fold less than either unrolled or processed bale feeding methods (Landblom et al., 2006). In our experiment, a common ring feeder was used instead of a tapered-cone feeder, which may have contributed to the similarity in intake and forage refusals between FEEDER, UNROLL, and PROCESSED.

Chopping harvested forages to decrease particle size can increase passage rate (Ehle, 1984; Firkins et al., 1986) and is thought to contribute to increased DMI by ruminants. Kononoff and Heinrichs (2003) demonstrated that DMI by dairy cows during early lactation increased

when particle size of alfalfa haylage (50% of diet DM) was reduced from an average of 18.1 mm to an average of 8.9 mm. Gherardi et al. (1992) reported an increase in DM intake for sheep when the particle length of hay was reduced from 21 to 4 mm. Elizalde and Henríquez (2009) reported a 31% increase in DMI for ewes consuming haylage that was chopped to a particle length of 20 mm compared to unchopped haylage. Similarily, Fitzgerald (2006) reported DM intakes in lambs increased as silage chop length decreased from 32.4 cm to 6.8 cm. Conversely, Landblom et al. (2006) reported intake of prairie hay by beef cattle decreased in response to processing. Chopping hay to an approximate particle length of 20 cm did not influence intake in our study compared to feeding hay in a common bale ring feeder or unrolling bales on the ground.

Similarities in amount and rate of DMI between the hay feeding methods in our trial were unexpected. Our assumption was that feeding processed hay to cow-calf pairs maintained on dormant native pastures would result in greater hay DMI and less refused hay compared to feeding hay in a common ring feeder or in the form of an unrolled bale. Reducing particle size should increase DMI because of increased passage rate and decreased rumination time (Firkins et al., 1986; Allen, 2000), whereas longer particle size should limit DMI due to increased ruminal fill, resulting in a slower passage rate (Gherardi et al., 1992). Gheradi et al. (1992) suggested reducing particle length from 21 mm to 4 mm increased the effectiveness of comminution during eating. Intake rates of forages were positively correlated with the size of particles swallowed by steers (Lee and Pearce, 1984).

Hutton et al. (2007) concluded that using a flail-type hay processor to reduce particle size of dry hay increased the dust and fines, potentially increasing DM losses to trampling and wind when feeding on the ground. In our study, the amount of residual hay remaining on tarped feeding sites after 24 h of access by cow-calf pairs was similar ($P = 0.28$) between bale-feeding systems (72.4, 134.2, 117.7 kg DM for FEEDER, UNROLL, and PROCESSED, respectively); however, our measurements did not include DM losses to wind that occurred during processing and did not distinguish between fresh hay and hay that may have been trampled. The amount of residual hay averaged 13.9, 25.7, and 22.5% of the amount of hay offered for FEEDER, UNROLL, and PROCESSED treatments, respectively. Therefore, availability of hay did not likely limit hay intake.

Blasi et al. (1993) compared feeding characteristics of large round hay bales that were either chopped or unrolled on the ground. They reported no differences in the amount of hay wastage between feeding methods when bales were fed on the ground. Conversely, Lechtenberg et al. (1974) reported that cattle consumed 29% more DM when feeding hay on the ground compared to feeding hay in racks. Feeding large round bales in common ring feeders was noted to be an effective means of reduced trampling, manure contamination, and wastage of hay (Buskirk et al., 2003; Landblom et al., 2006). Other researchers reported that feeding shredded hay into a bunk reduced hay wastage compared to feeding whole bales in round-bale feeders (Brasche and Russell, 1988). Any reduction in hay wastage resulting from feeding of processed hay is thought to result from less DM losses and more consistent DM intakes compared to bale feeders (Renoll et al., 1971; Brasche and Russell, 1988).

Feeding bales in intact or unrolled forms are the most commonly practiced methods of providing hay to cows during winter months in the central United States (Lenehan et al., 2005). Compared to using a bale feeder, unrolling hay disperses the bale, allowing timid cows to consume hay at the same time as more dominant cows; it allows also easy relocation of feeding sites within a pasture. Hay fed as an unrolled bale disperses forage across a larger area with a lesser chance of socially agonistic interactions among cows when compared to using a bale feeder. Reducing social agonistic interactions between cows at bale feeding sites could lessen feeding losses (Buskirk et al., 2003).

The average number of times per day that beef cows occupied feeding sites for FEEDER, UNROLL, and PROCESSED treatments were similar (3.3, 2.7, and 4.7 visits/d, respectively; $P = 0.19$). The total length of time per day and the average length of time per day that beef cows spent in the vicinity of hay feeding sites was similar ($P \geq 0.31$) also between treatments (Table 5.2). In spite of the fact that the quality of pasture forage was low, the cows in our study spent an average of more than 16 h away from bale feeding sites. Pasture forage likely contributed a significant proportion of daily cow DMI as a result. Assuming cows had a total DMI of 2.5% of BW, hay intake comprised between 49 and 56% of total DMI, whereas pasture forage intake comprised the remainder. Lenehan et al. (2005) reported that animal activity concentrated near bale feeders during winter. Familiarity with treatment pastures may have made the cows in our study capable of effective foraging even though average chemical composition of native forages was relatively poor (Launchbaugh and Howery, 2005).

There were no differences in the proportion of daytime ($P = 0.51$) and nighttime ($P = 0.98$) herd visits to the feeding sites between treatments in our study (Table 5.2). The similarity in overall and diurnal usage patterns between treatments was interpreted to indicate that round bale feeding method did not influence how the cows in our study spent idle time. Prior to the experiment, our assumption was that cows would spend more time in the vicinity of the feeding sites that allowed more comfortable opportunities for rest (i.e., unrolled or chopped hay fed on the ground on which cows may lay, rather than bales fed in common ring feeders). In production situations where hay is limit-fed as a supplement to cattle grazing low-quality pastures, perhaps the intake rate of the supplemental hay and the intensity of eating activities around the feeding site do not make it appealing as a resting site.

Our secondary objective for this experiment was to quantify how much of the string used to bind large, round hay bales was recovered from the flail tube of a flail-type hay processor versus that which might be expelled into the hay offered to cattle. Removing bale string from large round bales prior to processing or feeding is practiced routinely to prevent accidental ingestion of bale string by livestock (i.e., possibly causing damage to the gastrointestinal tract) and to prevent livestock from becoming entangled in bale string (i.e., possibly causing injury). The process of removing bale string prior to processing or feeding bales is time consuming; moreover, large quantities of intact bale string are difficult to store or discard. In general, the threat of animal injury is thought to decrease as the length of string present in hay that is offered to cattle decreases; therefore, livestock producers who routinely process hay may not take time to remove bale-binding string. Prior to the experiment, we speculated that the horizontal orientation of bales in a flail-type hay processor (i.e., binding-strings perpendicular to the flail hammers in the processor) would result in a majority of the binding string becoming wound on the flail tube of the hay processor rather than being expelled from the machine and into the hay offered to cattle. The amount of bale string removed from unprocessed bales prior to feeding was not different ($P = 0.87$) from the amount recovered from the flail tube of the hay processor after feeding processed bales (97.7 and 96.5 ± 5.1 g for unprocessed bales and processed bales, respectively; Table 5.3). Rasby (2009) suggested ingestion of large amounts of bale string could limit intake by filling up the rumen and could potentially cause gastrointestinal-tract obstruction leading to death. Our study raised the possibility that bale string may be largely recovered inside certain types of hay processors, leaving little to no bale string for accidental ingestion by cattle.

Implications

Under the conditions of our study, the time and expense needed to process supplemental hay for beef cows and calves was not justified. Chopping large round bales prior to feeding cows and suckling calves maintained on dormant native tallgrass pastures did not increase hay intake or decrease hay refusal when compared to feeding bales in a common bale feeder or unrolling them on the ground. Owners of flail-type hay processors may be able to forego manual removal of bale-binding string; our results indicated that little or no bale-binding string was discharged from a flail-type hay processor and into the forage offered to beef cattle.

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Table 5.1 Effects of round-bale feeding method on hay intake by beef cows and suckling calves maintained on dormant native tallgrass pastures and residual hay remaining after 24 h of access

Item	Treatment [a]			SEM	P-value
	FEEDER	UNROLL	PROCESSED		
Total hay intake, kg DM/d [b]	372.5	321.5	347.4	27.10	0.45
Daily hay intake, kg DM/cow	7.5	6.6	7.1	0.53	0.52
Hay intake rate, kg DM/h	0.32	0.27	0.30	0.02	0.50
Residual hay, kg DM/d	72.4	134.2	117.7	25.93	0.28

[a] FEEDER = bales fed in a common ring feeder; UNROLL = bales unrolled on the ground; PROCESSED = bales chopped with a flail-type hay processor deposited into 2 parallel windrows on the ground (approximate particle length = 20 cm).

[b] Total hay intake represents the amount of DM consumed in 24 h by 50 cows with suckling calves.

Table 5.2 Effect of round bale feeding method on frequency, duration, and timing of visits to round-bale feeding sites by beef cows and suckling calves maintained on dormant native tallgrass pastures

Item	Treatment [a]			SEM	P-value
	FEEDER	UNROLL	PROCESSED		
Frequency of herd visits, no./d	3.3	2.7	4.7	0.71	0.19
Total herd visit duration, min/d	444	547	430	99.5	0.67
Mean herd visit duration, min/visit	185	239	99	60.5	0.31
Daytime visits, % [b]	44	34	49	0.1	0.51
Nighttime visits, % [b]	43	44	45	0.1	0.98
Daytime visits, No./d	1.5	1.1	2.3	0.57	0.39
Nighttime visits, No./d	1.5	1.1	2.1	0.30	0.13

[a] FEEDER = bales fed in a common ring feeder; UNROLL = bales unrolled on the ground; PROCESSED = bales chopped with a flail-type hay processor deposited into 2 parallel windrows on the ground (approximate particle length = 20 cm).

[b] The percentage of all visits which occurred during the daytime (0600 to 1800) or nighttime (1800 to 0600) hours. Percentages do not equal 100 because some visits spanned both daytime and nighttime hours.

Table 5.3 Amount of bale string physically removed from large round bales offered in an unprocessed form compared to bale string removed from the flail tube of a flail-type hay processor (n = 16)

	Treatment [a]			
Item	Unprocessed	Processed	SEM	P-value
Bale string, g	97.7	96.5	5.14	0.87

[a] Unprocessed = bales fed in a common ring feeder or unrolled on the ground; Processed = bales chopped to a particle length of approximately 20 cm with a flail-type hay processor.