2012

TECHNICAL NOTE: Estimating beef-cattle forage demand: Evaluating the animal unit concept

T. L. Meyer
West Central Research and Extension Center, University of Nebraska–Lincoln, tl.meyer@live.com

L. A. Stalker
University of Nebraska–Lincoln, stalkera@byui.edu

J. D. Volesky
University of Nebraska–Lincoln, jvolesky1@unl.edu

D. C. Adams
West Central Research and Extension Center, University of Nebraska-Lincoln, dadams1@unl.edu

R. N. Funston
West Central Research and Extension Center, University of Nebraska–Lincoln, rfunston2@unl.edu

See next page for additional authors

Authors
T. L. Meyer, L. A. Stalker, J. D. Volesky, D. C. Adams, R. N. Funston, T. J. Klopfenstein, and Walter H. Schacht

The Professional Animal Scientist 28 (2012):664–669

TECHNICAL NOTE: Estimating beef-cattle forage demand: Evaluating the animal unit concept

T. L. Meyer,* L. A. Stalker,*[1] J. D. Volesky,* D. C. Adams,* R. N. Funston,* T. J. Klopfenstein,† and W. H. Schacht‡

*West Central Research and Extension Center, University of Nebraska–Lincoln, North Platte 69101; and †Department of Animal Science, and ‡Department of Agronomy and Horticulture, University of Nebraska–Lincoln, Lincoln 68583

ABSTRACT

The objective of this experiment was to evaluate the effect of BW and physiological status of a beef animal on forage intake. The experiment was repeated over 2 yr with 6 replications of 3 treatments per year: cow-calf pair (CCP, BW = 629 kg), nonlactating cow (NLC, BW = 503 kg), and yearling steer (YS, BW = 305 kg). The CCP was treated as one unit, with the sum of cow BW and calf BW comprising CCP BW. Calves averaged 42 d of age and 73 kg at the start of the experiment each year. Animals were housed in individual pens and fed grass hay harvested from subirrigated meadow (11% CP) in quantities sufficient for ad libitum intake. Intake of DM, OM, DM that disappeared in vitro, and NDF were greatest ($P < 0.01$) for CCP, intermediate for NLC, and least for YS. As a percentage of BW, the CCP had greater ($P < 0.01$) intake of DM, OM, DM that disappeared in vitro, and NDF than did both the NLC and YS, which were not different ($P > 0.05$) from each other. When expressed as a percentage of metabolic BW ($BW^{0.75}$), intake of DM, OM, DM that disappeared in vitro, and NDF were greatest ($P < 0.01$) for CCP, intermediate for NLC, and least for YS. Results indicate that intake differences among cattle of different physiological states should be considered when calculating forage demand for stocking rate or feeding purposes.

Key words: animal unit, forage intake, beef cattle, physiological state

INTRODUCTION

Grazing is an important component of beef-cattle production systems, and careful management is needed to sustainably use forage resources. Matching the DMI requirements of an animal with available forage is necessary for optimal beef production and sustainability. Balancing forage supply and animal demand is commonly achieved by defining both in terms of an animal unit (**AU**). The AU concept is widely used in grazing-management strategies, but there are multiple definitions of the term (Hinnant, 1994) and there is not general consensus about what constitutes an AU nor how much forage a standard grazing animal consumes (Scarnecchia, 1985). Scarnecchia and Kothmann (1982) defined AU intake as animal demand equivalent to about 11.8 kg/d (DM), with an AU month being the amount of forage DM an AU consumed in 1 mo (354 kg of DM). Waller et al. (1986) and Ohlenbusch and Watson (1994) defined an AU as a 454-kg cow of above-average milking ability with a calf less than 3 to 4 mo postpartum and an AU month as 308 kg (DM) of forage. Redfearn and Bidwell (2003) described an AU simply as a 454-kg cow with calf, with no age of calf given. Reynolds et al. (2000) defined forage demand of an AU equivalent (**AUE**) as 0.001 × 45.4 kg of animal BW but equated a nonlactating, 454-kg cow to 0.9 AU. The SRM (1998) and ISU (1998) considered an AU one mature cow of about 454 kg, either nonlactating or with calf up to 6 mo of age, and assumed they consume 11.8 kg (DM) of forage per day. Gerrish and Roberts (1999) defined an AU as a 499-kg cow without calf and an AU month about 454 kg (DM) of forage. Given the im-

[1] Corresponding author: astalker@unlnotes.unl.edu

Table 1. Average monthly temperature and precipitation

Item	May	June	July	August
Yr 1 average temperature, °C	13	18	25	21
Yr 2 average temperature, °C	13	23	26	—
Yr 1 precipitation, cm	3.71	4.85	16.13	1.65
Yr 2 precipitation, cm	3.23	3.28	1.24	—

portance of properly balancing animal demand with forage supply and the discrepancy among AU definitions, it is imperative to know which factors need to be accounted for when defining an AU. Allison (1985) listed body size, physiological status, body condition, supplementation, forage preference, forage availability, and grazing systems as factors affecting forage intake. It was hypothesized both BW and physiological status would affect DMI; therefore, the objective of this experiment was to evaluate the effect of BW and physiological state on forage intake and compare it to standard AU intake values.

MATERIALS AND METHODS

All animal procedures were approved by the University of Nebraska Institutional Animal Care and Use Committee. This project was repeated over 2 yr, with yr 1 located at the University of Nebraska Gudmundsen Sandhills Laboratory (**GSL**), near Whitman, Nebraska, and yr 2 at the University of Nebraska West Central Research and Extension Center, North Platte, Nebraska. Temperature and precipitation data for each location and year are shown in Table 1.

Twenty-four MARC II (1/4 Angus, 1/4 Gelbvieh, 1/4 Hereford, and 1/4 Simmental) composite cattle were used each year in the experiment. There were 6 replications of 3 treatments each year: cow-calf pair (**CCP**, BW = 629 kg), nonlactating cow (**NLC**, BW = 504 kg), and yearling steer (**YS**, BW = 305 kg). Cow-calf pair BW was the sum of cow BW and the mean calf BW during the experiment and was treated as a single unit. Calf age and BW averaged 42 d and 73 kg, respectively, at the start of the experiment each year. Animals were housed and fed individually (or as a pair in the case of the CCP) in 18 outdoor pens (10 m × 30 m) with water and salt provided ad libitum. Following an adaptation period, intake was measured for 13 wk in yr 1 and 9 wk in yr 2. Intake data collected during a single week in yr 1 were excluded from the analysis because of extreme precipitation (15 cm) resulting in depressed intake and impaired collection of orts.

Animals were offered hay (Table 2) harvested from subirrigated meadow at GSL. The meadow at GSL is dominated by cool-season grasses including slender wheatgrass [*Elymus trachycaulus* (Link) Matte], redtop bent (*Agrostis stolonifera* L.), timothy (*Phleum pratense* L.), Kentucky bluegrass (*Poa pratensis* L.), and smooth bromegrass (*Bromus inermis* Leyss.). Grass-like plants including woolly sedge (*Carex lanuginosa* Michx.) and spike rush (*Eleocharis* spp.) are common, as are forbs such as white clover (*Trifolium repens* L.), alsike clover (*Trifolium hybridum* L.), and red clover (*Trifolium pratense* L.). The plant-species composition of GSL subirrigated meadows is described in greater detail by Volesky et al. (2004). Hay was harvested in mid-June each year from the same meadow and fed the year after it was harvested. Hay was fed unprocessed (i.e., long stem), offered ad libitum in bunks, and delivered once daily. Steel, free-standing bunks were used in yr 1 and in-line, cement bunks were used in yr 2. In both years, 6 m of bunk space was provided in each pen. No attempt was made to prevent the calf in the CCP treatment from consuming hay.

Dry matter content of the hay offered was determined from samples collected daily and composited within week. Orts (including any hay lost from the bunk that could be collected) from each pen were collected and weighed weekly in yr 1 and daily in yr 2. In yr 2, orts were composited by week before analysis.

Lactating cow and NLC BW measured at the start of the experiment was used in the analysis. Mean BW between starting and final BW was used for YS and calf BW. Cow BW and calf BW were summed to calculate CCP BW. Metabolic body weight (**MBW**) was calculated as $BW^{0.75}$.

Retrospective to the primary analysis, alternate calculations of CCP intake as a percentage of BW were conducted based on differential accounting of calf BW and DMI. The first alternate calculation assumed

Table 2. Laboratory analysis of hay offered, refused, and apparently consumed by cow-calf pairs, nonlactating cows, and yearling steers

	Yr 1			Yr 2		
Item[1]	Offered	Refused	Actual diet	Offered	Refused	Actual diet
DM, %	84.1	76.4	—	79.7	85.8	—
OM, %	90.5	85.5	91.3	89.9	89.8	89.9
NDF, %	64.3	70.0	63.8	67.2	76.5	66.2
CP, %	11.6	10.5	11.9	10.7	10.2	11.1
IVDMD, %	52.6	48.4	53.2	51.8	46.5	52.9
IVOMD, %	56.1	52.4	56.7	55.4	50.7	56.4
RUP, % of CP	41.4	46.4	40.9	45.5	53.2	44.1

[1]IVOMD = in vitro OM disappearance.

Table 3. Starting BW and ADG of yearling steers (YS), nonlactating cows (NLC), lactating cows (LC), and calves (Calf) consuming grass hay harvested from Sandhills meadow

Item	YS	NLC	LC	Calf	SE	*P*-value
Start BW, kg	275	503	513	73	15	<0.01
End BW, kg	335	558	529	158	14	<0.01
ADG, kg/d	0.69	0.64	0.21	0.99	0.05	<0.01

the cow consumed 100% of the hay offered to the pair and calf BW was subtracted from the total BW. In the second alternate calculation, calf BW was subtracted and an assumed DMI of 1.5 kg by the calf was subtracted from the total DMI of the CCP. The assumed calf DMI (1.3% of BW) was the amount reported by Hollingsworth-Jenkins (1994) for nursing calves at GSL. Both calf BW and forage quality were similar to those used in the present experiment.

Diet and ort samples were weighed, placed in a 60°C forced-air oven for 48 h, and then reweighed for DM determination. Dry samples were ground to pass a 2-mm screen in a Wiley mill (Arthur Thomas, Philadelphia, PA), and then a portion was ground to pass a 1-mm screen. Diet and ort samples were analyzed for OM and CP by standard methods (AOAC, 1996). Diet and ort samples were also analyzed for IVDMD, NDF, and RUP content. For NDF analyses, 0.5 g of diet or ort sample ground to pass a 1-mm screen was placed in filter bags, heat sealed, and placed in a bag suspended in neutral detergent solution in an Ankom 200 fiber analyzer (Ankom Inc., Fairport, NY). Samples were agitated for 70 min and rinsed 3 times with boiling distilled water. Bags were then placed in a drying oven at 60°C for 12 h before weighing.

Two ruminally fistulated cows maintained on a meadow-hay (8.3% CP, 55% NDF) diet offered once daily at 1.5% of BW provided inoculum for IVDMD analysis. The method described by Tilley and Terry (1963) was modified by the addition of 1 g/L of urea to McDougall's buffer (Weiss, 1994) exactly following the procedure explained by Stalker et al. (2012). Five forages with known in vivo digestibility were included in the in vitro procedures. The IVDMD of hay used in this experiment was then adjusted to in vivo digestibility by regressing the observed IVDMD of each forage standard against its known in vivo digestibility within each run as described by Stalker et al. (2012).

In situ incubations were replicated using 2 bags per sample per ruminally fistulated cow, resulting in 4 bags per sample. The same 2 ruminally fistulated cows from which IVDMD inoculum was obtained were used for in situ incubations. Dacron bags (5 × 10 cm; Ankom Inc.) with an average pore size of 50 μM were filled with 1.25 g of dried hay or ort sample ground to pass a 2-mm screen. Incubation times included 0 h and 27 h. Following incubation, bags were hand washed and refluxed in neutral detergent solution using an Ankom 200 fiber analyzer (Ankom Inc.) to remove microbial contamination (Mass et al., 1999) and dried for 48 h at 60°C. Bags were weighed and then air-equilibrated and reweighed, and residues were analyzed for nitrogen by combustion (AOAC, 1996) using a Leco FP-528 nitrogen analyzer (Leco Corp., St. Joseph, MI).

Data were analyzed using the MIXED procedure of SAS (SAS Institute Inc., Cary, NC). The model included the effects of treatment as a fixed effect and year as a random effect. Individual animal or CCP was used as the experimental unit, with $P < 0.05$ considered significant.

RESULTS AND DISCUSSION

Starting BW and ADG for YS, NLC, and lactating cow and calf are shown in Table 3. In this experiment, hay quality was similar to diet quality reported in previous studies conducted on summer Sandhills range and meadow (Hollingsworth-Jenkins, 1994; Lardy et al., 2004). Yearling steer and cow and calf performance were similar to results reported from experiments using grazing animals in the Nebraska Sandhills (Jordon, 2000; Stalker et al., 2006), suggesting results from the present experiment are applicable in grazing situations.

Intake was analyzed on DM, OM, IVDMD, and NDF bases and expressed 3 ways: actual intake, intake as a percentage of BW, and intake as a percentage of MBW (Table 4). Lactating cow and NLC starting BW was used in the analysis, and mean BW between starting and final BW was used for YS and calf BW. Cow BW and calf BW were added to calculate CCP BW. Actual DM, OM, DM that disappeared in vitro, and NDF intake were different ($P < 0.05$) among treatments, with CCP consuming the most, followed by NLC, and YS consuming the least. Intake of DM, OM, DM that disappeared in vitro, and NDF as a percentage of BW were greater ($P < 0.01$) for the CCP than for the NLC and YS, which were not different ($P > 0.05$) from each other. When expressed as a percentage of metabolic BW, intake of DM, OM, DM that disappeared in vitro, and NDF were greatest ($P < 0.01$) for CCP, intermediate for NLC and least for YS.

These results clearly demonstrate the importance of accounting for not just BW but also physiological status of cattle when calculating forage demand. Actual DMI, DMI as a percentage of BW, and DMI as a percentage of MBW were all greatest for CCP, which included both cow and calf BW and DMI. Because nutrient requirements of lactating cows are greater than those of nonlactating cows (NRC, 1996), one would also expect their intake to be greater. Vanzant et al. (1991) reported OM intake was 16% greater for lactating heifers compared with nonlactating heifers about 26 d after parturi-

Table 4. Average BW, metabolic BW (MBW), DM, OM, IVDMD, and NDF daily intake by year of cow-calf pairs (CCP), nonlactating cows (NLC), and yearling steers (YS) consuming grass hay harvested from Sandhills meadow

Item	CCP	NLC	YS	SE	P-value
BW,[1] kg	629[a]	503[b]	305[c]	18	<0.01
MBW,[2] kg	126[a]	106[b]	73[c]	3	<0.01
DMI, kg	16.2[a]	11.8[b]	6.8[c]	1.3	<0.01
DMI, % of BW	2.58[a]	2.37[b]	2.23[b]	0.21	<0.01
DMI, % of MBW	12.9[a]	11.1[b]	9.3[c]	1.3	<0.01
OMI,[3] kg	14.7[a]	10.7[b]	6.2[c]	1.2	<0.01
OMI, % of BW	2.34[a]	2.15[b]	2.03[b]	0.20	0.01
OMI, % of MBW	11.7[a]	10.1[b]	8.5[c]	1.2	<0.01
IVDMDI,[4] kg	8.6[a]	6.3[b]	3.7[c]	0.7	<0.01
IVDMDI, % of BW	1.38[a]	1.26[b]	1.20[b]	0.12	0.01
IVDMDI, % of MBW	6.8[a]	5.9[b]	5.1[c]	0.7	<0.01
NDFI,[5] kg	10.5[a]	7.7[b]	4.4[c]	0.7	<0.01
NDFI, % of BW	1.67[a]	1.49[b]	1.45[b]	0.08	<0.01
NDFI, % of MBW	8.3[a]	7.3[b]	6.0[c]	0.6	<0.01

[a–c]Within a row, means without common superscript letters differ ($P < 0.05$).

[1]Cow-calf pair BW calculated as lactating cow BW at start of experiment plus mean BW of calf. Nonlactating cow BW calculated as BW at start of experiment. Yearling steer BW calculated as mean BW.

[2]Metabolic BW = $BW^{0.75}$.

[3]OM intake.

[4]IVDMD intake.

[5]NDF intake.

tion. Patterson et al. (2003) reported nonlactating cows removed 28% less grazed forage than did cow-calf pairs. The mechanism whereby a lactating cow could have greater DMI than a nonlactating cow of similar BW may be related to changes in digesta passage rate. Intake of poorly digestible, low-energy diets is thought to be controlled mostly by physical factors such as ruminal fill and digesta passage, whereas consumption of highly digestible, high-energy diets is controlled by the energy demands of the animal and metabolic factors (NRC, 1987). Allison (1985) cited evidence indicating voluntary intake of forage diets is limited by reticulorumen capacity and rate of digesta disappearance from the reticulorumen. When offered poor-quality forages, cattle eat to a constant ruminal fill. However, physiological status is known to affect ruminal capacity and digesta passage rate. For example, Stanley et al. (1993) used late-gestating and early-lactating crossbred cows to monitor periparturient changes in DMI, ruminal capacity, and digestion and fermentation characteristics and concluded increased passage rate was one way increased nutrient demand is accommodated in the presence of decreasing ruminal capacity. Because BW of the CCP and NLC were similar, their reticulorumen capacity would be expected to be similar also. Even though degree of fill and reticulorumen capacity of the lactating cow and NLC used in the present experiment were assumed not different, changes in digestive physiology associated with lactation, such as increased digesta passage rate, may have allowed the lactating cow to increase DMI. However, not all the difference in DMI between CCP and NLC is attributable to increased intake by the cow. Calves were observed eating hay, but cow and calf intake was not measured separately.

Results of the present experiment also demonstrate how the manner in which DMI of the calf is accounted affects the overall forage demand calculation. In Table 5, CCP DMI is presented along with 2 alternate methods of expressing DMI depending on how calf BW and DMI are accounted. The first alternate calculation assumes the cow consumed 100% of the hay offered to the pair and uses the actual intake for the CCP (16.2 kg DM) but subtracts the calf BW (116 kg) from the total BW, resulting in a DM intake of 3.16% of BW. The second alternate intake calculation subtracts the calf BW and subtracts a predicted DMI of 1.5 kg by the calf from the total DMI of the cow-calf pair, resulting in a DMI of 2.87% of BW. Reports of nursing calf forage DMI are rare in the literature. The predicted calf DMI (1.3% of BW) comes from Hollingsworth-Jenkins (1994). Hollingsworth-Jenkins (1994) measured intake of calves similar in age to the present experiment and found they consumed between 1.1 to 1.5% of their BW.

Many recommended methods of calculating forage demand do not consider DMI of the calf (Hinnant, 1994; SRM, 1998). These data illustrate the necessity of accounting for both the BW and DMI of the calf. Future research should measure calf and cow DMI separately.

Actual DMI observed was similar to some recommended DMI values but differed from others. Dry matter intake values for a lactating cow in the present experiment are similar to values offered by ISU (1998), the SRM (1998), and Scarnecchia and Kothmann (1982). None of these make a distinction between lactating and nonlactating cows and would, therefore, overestimate DMI of NLC. Likewise, other reported AUE intake values were greater than actual forage DMI of NLC or YS from the present experiment (Gerrish and Roberts, 1999). The DMI Waller et al. (1986) provided for a lactating cow is similar to this experiment's NLC DMI, but their estimate for a YS was greater than YS actual DMI.

The intake values predicted by the NRC (1996) model were compared

Table 5. Comparison of DMI (actual and as a percentage of BW) across both years of cow-calf pair (CCP), nonlactating cow (NLC), yearling steer (YS), CCP with calf BW removed, and lactating cow only

Item	CCP	NLC	YS	CCP minus calf BW[1]	Lactating cow minus calf BW and intake[2]
BW, kg	629	503	305	513	513
DMI, kg	16.2	11.8	6.8	16.2	14.7
DMI, % of BW	2.58	2.35	2.23	3.16	2.87

[1]Average calf BW (116 kg) subtracted from average CCP BW.

[2]Average calf BW (116 kg) subtracted from average CCP BW and assumed calf DMI (1.3% of BW) subtracted from CCP DMI.

with results from the present experiment. Using the average beginning NLC BW (503 kg), the NRC model predicted 9.5 kg of intake or about 1.9% of BW. If the NLC intake from the present experiment of 11.7 kg is fed, the NRC model predicted 68 d to gain 1 BCS. The NRC model predicted lactating-cow (513 kg) intake of 13.1 kg and 33 d to lose 1 BCS. The SRM (1998) and ISU (1998) definitions do not measure calf intake until 6 mo. If this standard is used in the model, it is assumed 16.2 kg of DMI is consumed solely by the lactating cow, and it would take 1,261 d to gain 1 BCS. The lactating cows in this experiment maintained a constant BW throughout in agreement with the NRC (1996) prediction. The NRC (1996) model overpredicted YS intake (7.7 kg/d predicted vs. 6.8 kg/d actual) and underpredicted YS ADG (0.19 kg/d predicted vs. 0.7 kg/d actual). If the net energy adjusters are set to 120% as Block et al. (2006) recommend, YS intake is even further overpredicted (8.0 kg predicted vs. 6.8 kg actual) and YS ADG prediction (0.41 kg) is still much lower than actual.

IMPLICATIONS

Most estimates of livestock forage demand and AUE consider only animal BW. Results from this research indicate intake differences among cattle of different physiological states should also be considered when calculating forage demand, further increasing accuracy of forage-demand estimates for stocking rate or feeding purposes. Cow-calf pair DMI, when expressed on a percentage of MBW basis, was about 15% greater than for NLC and about 28% greater than for YS. The greater intake per unit BW should be considered when calculating AUE for cow-calf pairs and nonlactating cows.

LITERATURE CITED

Allison, C. D. 1985. Factors affecting forage intake by range ruminants: A review. J. Range Manage. 38:305–311.

AOAC. 1996. Official Methods of Analysis. 16th ed. AOAC, Arlington, VA.

Block, H. C., T. J. Klopfenstein, and G. E. Erickson. 2006. Evaluation of average daily gain prediction by level one of the 1996 National Research Council beef model and development of net energy adjusters. J. Anim. Sci. 84:866–876.

Gerrish, J. R., and C. A. Roberts. 1999. Missouri Grazing Manual. MU Ext. M157., Univ. Missouri, Columbia.

Hinnant, R. T. 1994. What is an animal unit? A time to conform. Rangelands 16:33–35.

Hollingsworth-Jenkins, K. J. 1994. Escape protein, rumen degradable protein, or energy as the first limiting nutrient of nursing calves grazing Sandhills range. PhD Dissertation. Univ. Nebraska, Lincoln.

ISU (Iowa State University). 1998. Pasture Management Guide for Livestock Producers. Publ. No. PM-1713. Iowa State Univ. Ext., Ames, Pages 70 and 98.

Jordon, D. J. 2000. Performance and slaughter breakeven analysis of calf and yearling systems and compensatory growth. PhD Dissertation. Univ. Nebraska, Lincoln.

Lardy, G. P., D. C. Adams, T. J. Klopfenstein, and H. H. Patterson. 2004. Building beef cow nutritional program with the 1996 NRC beef cattle requirements model. J. Anim. Sci. 82(E. Suppl.):E83–E92.

Mass, R. A., G. P. Lardy, R. J. Grant, and T. J. Klopfenstein. 1999. In situ neutral detergent insoluble nitrogen as a method for measuring forage protein degradability. J. Anim. Sci. 77:1565–1571.

NRC. 1987. Predicting Feed Intake of Food-Producing Animals. Natl. Acad. Press, Washington, DC.

NRC. 1996. Nutrient Requirements of Beef Cattle. 7th rev. ed. Natl. Acad. Press, Washington, DC.

Ohlenbusch, P. D., and S. L. Watson. 1994. Stocking rate and grazing management. Kansas State Univ. Ag. Exp. Stn. Coop. Ext. Serv. MF-1118. Accessed Apr 13, 2012. http://www.ksre.ksu.edu/library/crpsl2/MF1118.pdf.

Patterson, H. H., T. J. Klopfenstein, D. C. Adams, and J. A. Musgrave. 2003. Supplementation to meet metabolizable protein requirements of primiparous beef heifers: I. Performance, forage intake, and nutrient balance. J. Anim. Sci. 81:800–811.

Redfearn, D. D., and T. G. Bidwell. 2003. Stocking rate: The key to successful livestock production. Oklahoma Coop. Ext. Serv. PSS-2871. Accessed Apr 13, 2012. http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-2050/PSS-2871web.pdf.

Reynolds, D., J. Waggoner, and M. Smith. 2000. Cattle management manual. Univ. Wyoming Coop. Ext. Serv. MP-97. Accessed Apr 13, 2012. http://www.wyomingextension.org/agpubs/pubs/MP-97.pdf.

Scarnecchia, D. L. 1985. The animal-unit and animal-unit-equivalent concepts in range science. J. Range Manage. 38:346–349.

Scarnecchia, D. L., and M. M. Kothmann. 1982. A dynamic approach to grazing management terminology. J. Range Manage. 35:262–264.

SRM (Society for Range Management). 1998. Glossary of Terms Used in Range Management. Soc. Range Manage., Denver, CO.

Stalker, L. A., D. C. Adams, T. J. Klopfenstein, D. M. Fuez, and R. N. Funston. 2006. Effects of pre- and postpartum nutrition on reproduction in spring calving cows and calf feedlot performance. J. Anim. Sci. 84:2582–2589.

Stalker, L. A., B. G. Lorenz, N. A. Ahern, and T. J. Klopfenstein. 2012. Inclusion of forage standards with known in vivo digestibility in in vitro procedures. Livest. Sci. 145. In press.

Stanley, T. A., R. C. Cochran, E. S. Vanzant, D. L. Harmon, and L. R. Corah. 1993. Periparturient changes in intake, ruminal capacity, and digestive characteristics in beef cows consuming alfalfa hay. J. Anim. Sci. 71:788–795.

Tilley, J. M. A., and R. A. Terry. 1963. A two-stage technique for the in vitro digestion of forage crops. J. Br. Grassl. Soc. 18:104–110.

Vanzant, E. S., R. C. Cochran, and D. E. Johnson. 1991. Pregnancy and lactation in beef heifers grazing tallgrass prairie in the winter: Influence on intake, forage utilization, and grazing behavior. J. Anim. Sci. 69:3027–3038.

Volesky, J. D., W. H. Schacht, and D. M. Richardson. 2004. Stocking rate and grazing frequency effects on Nebraska Sandhills meadows. J. Range Manage. 57:553–560.

Waller, S. S., L. E. Moser, and B. Anderson. 1986. A Guide for Planning and Analyzing a Year-Round Forage Program. Nebraska Coop. Ext. EC86–113-C, Lincoln, NE.

Weiss, W. P. 1994. Estimation of digestibility of forages by laboratory methods. Pages 644–681 in Forage Quality, Evaluation, and Utilization. G. C. Fahey Jr., ed. Am. Soc. Agronomy, Crop Sci. Soc. Am., Soil Sci. Soc. Am., Madison, WI.