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Estimating Livestock Forage Demand: Defining the Animal Unit

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ESTIMATING LIVESTOCK FORAGE DEMAND:

DEFINING THE ANIMAL UNIT

by

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The objective of this experiment was to evaluate the effect of a beef animal's physiological status on forage intake. The experiment was repeated over two years with six replications of three treatments per year: cow-calf pair (CC; BW = 629 kg), dry cow (DC; BW = 503 kg), and yearling steer (S; BW = 305 kg). The cow and calf were treated as one unit, with cow BW and calf BW comprising CC BW. Calves were approximately 42 d of age and weighing 73 kg at the start of each year. Animals were housed in individual pens and fed high quality (11.6% CP) meadow hay *ad libitum* daily. Daily diet samples were composited by week and analyzed for dry matter (DM), organic matter (OM), *in* vitro dry matter disappearance (IVDMD), neutral detergent fiber (NDF), and undegradable intake protein (UIP). Refusals were collected, composited by week per pen, and analyzed for DM, OM, IVDMD, and NDF. Refusals were also composited for each year by pen and evaluated for UIP. Data was analyzed using the MIXED procedure of SAS. The cow-calf pair had the largest DMI, followed by the dry cow, and then the yearling steer ($P < 0.01$). A year × treatment effect was present. In year 1, cow-calf pairs had the highest intake as %BW, followed by dry cows, and then yearling steers ($P < 0.01$). In year 2, DMI as % BW was different between the cow-calf pairs and dry cows ($P < 0.01$). Cow-calf pairs and yearling steers were the same ($P = 0.31$), as were the dry cows and yearling steers ($P = 0.12$). Dry matter intake as % metabolic BW was the same for cow-calf pairs and dry cows ($P = 0.51$). Results indicate intake differences among cattle of different physiological states or classes should be considered when calculating forage demand for stocking rate or feeding purposes.

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Acknowledgements

"It has often been said there's so much to be read, you never can cram all those words in your head. So the writer who breeds more words than he needs is making a chore for the reader who reads. That's why my belief is the briefer the brief is, the greater the sigh of the reader's relief is."

Theodor Seuss Geisel, American writer and cartoonist

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Literature Review

This literature review will focus on animal and plant factors affecting intake, intake control mechanisms, methods used to measure intake, and the animal unit (AU) concept.

Animal-related factors affecting intake

Factors affecting a ruminant's forage intake are numerous. Differences in voluntary dry matter intake account for more than 50% of the variation in digestible nutrient consumption by ruminants (Allen, 1996).

Physiological status of animal

Body weight and body condition scoring (BCS). Rate of particle size breakdown is probably related to animal size, because rumination time per gram of NDF decreases exponentially with BW (Welch, 1982). The AU is often defined on a BW basis (see Table 1). Data presented in the NRC (1987) indicates the degree of fatness and/or a reduction in demand for growth influence voluntary intake. Intake is related to body condition as well as body size. Body condition often varies more in grazing animals than in penned animals. In a grazing herd, live weights of mature animals vary over time, and body condition varies among individuals (Allison, 1985).

Lactation/stage of gestation. Stanley et al. (1993) used late gestation, early lactation crossbred cows to monitor periparturient changes in DMI, ruminal capacity and digestion and fermentation characteristics. They concluded increased passage rate was one way increased nutrient demand is accommodated in the presence of decreasing ruminal capacity. According to data presented in the NRC (2000), maintenance requirements of lactating cows are about 20% higher than those of non-lactating cows. Cows consumed 69% more DM postpartum compared to 61 d before calving (Stanley et al., 1993). Lactating cows, like sheep and growing cattle, are capable of controlling intake to maintain a constant DE level, provided the diet has a DE concentration above the critical point. This critical point is variable, depending upon the physiological demands for substrate (NRC, 1987). Data presented in the NRC (1987) indicate voluntary intake in beef cows is similar to growing cattle when adjusted for the effect of milk production. Lactating cows in the same study consumed 2.0 to 2.6% of their BW on an OM basis.

Vanzant et al. (1991) reported OM intake was 16% greater for lactating heifers versus non-lactating controls approximately 26 d after parturition, noting intake was significantly different between the two groups but may have been more so later in lactation. There was no difference in ruminal fill and capacity between the two groups. Passage rate of insoluble acid detergent fiber (IADF) was consistently greater for pregnant and subsequently, lactating heifers than control heifers throughout the trial; with Vanzant et al. (1991) suggesting this was due to an increase in rumination time. When grazing native tallgrass prairie during the winter months, pregnant heifers approximately 2 mo before calving had greater intakes than control heifers. Grazing time was decreased in pregnant heifers a few days before calving, but intake by pregnant heifers and controls was similar 2 wk before calving. Lactation prompted an increase in intake and grazing time. The absence of intake differences between treatment groups in late pregnancy may have been partially a result of changes in ruminal capacity and fill associated with fetal growth (Vanzant et al., 1991). Patterson et al. (2003) reported protein supplemented, March-calving, primiparous, 2-yr-old heifers decreased their grazed forage intake from 1.9% of BW in November to 1.1% of BW in February.

Age. NRC (2000) suggested maintenance of mature, productive cows is not less than younger, growing animals post weaning. Calves 66 ±4 d of age with access to high quality diets were able to increase forage intake rapidly in response to decreased milk intake (Ansotegui, 1991).Young calves (75 d), grazing blue grama rangelands (ave. NDF = 77%) were not able to increase forage organic matter intake when milk intake was restricted (Sowell et al., 1995). This would imply forage intake by calves grazing low-quality pastures is limited by bulk fill. Yearlings vs. calves typically consume more feed per unit of BW, presuming age relative to proportion of mature body composition for yearling cattle prompts greater feed intake (NRC, 2000). Hollingsworth-Jenkins et al. (1995) measured intake of calves approximately 80 d of age and found they consume from 1.1 to 1.5% of their BW on an OM basis. Hollingsworth-Jenkins et al. (1995) also concluded nursing calves grazing native Sandhills summer range select diets higher in rumen DP than their dams. Results from research conducted by Ansotegui and others (1991) indicated calves nursing low-milk-producing cows consume more forage than those calves nursing high-milk producing cows, but the increased forage consumption by the calf did not imply more forage was necessary for the low-milk producing cow and her calf.

Sex. NRC (2000) concluded maintenance requirements of bulls are 15% higher than steers or heifers of the same genotype. Heifers are fatter than steers at a given BW, so Fox et al. (1988) used a frame-equivalent adjustment instead of directly adjusting for sex.

Breed differences/genetic variance. NRC (2000) points out considerable variation exists in maintenance requirements among cattle germplasm resources. Due to the many variations, NRC (2000) generalized a positive relationship exists between maintenance requirement and genetic potential for measures of productivity. In addition, several papers cited within the NRC suggested animals having genetic potential for high productivity may be at a disadvantage in nutritionally or environmentally restrictive environments. Data presented in the NRC (1987) indicate progress can be made in intake and use of consumed nutrients by selecting for increased relative growth rate. Increased genetic potential for growth likely stimulates intake as a result of greater demand for production.

Intake differences among beef cattle breeds and their crosses may largely be accounted for by differences in mature size (NRC, 1987). Kronberg et al. (1986) compared forage intake between Hereford (HH) and 3/4 Simmental- 1/4 Hereford (SH) and found the lactating SH had a higher daily forage intake (1.9% BW) than the lactating Hereford cows (1.7% BW). However, there were no intake differences between non-lactating cattle in both treatments. When examining factors of the statistical model, lactation status was the only significant factor explaining differences in intake between non-lactating and lactating cows. This suggests supposed milk production differences between HH and SH cows may be the most important factor in explaining their intake differences. With the large metabolizable energy requirement for milk production, it is possible breed differences in intake seen in this study are partially due to the greater energy demand of lactation resulting in increased forage consumption during the summer grazing season.

As the cow's energy demand attributable to lactation rises, forage intake should also increase. The significance of breed as a factor explaining the variation in intake of lactating cows may lessen with diets of lower quality. Animal related factors, such as cow body condition, calf sex, age, and size, and physiological and digestive system parameters may also influence the breed differences in intake reported in Kroneberg's (1986) study.

Water. Water intake from feeds plus what is consumed ad libitum is approximately equivalent to the water requirements of cattle. Restriction of water intake reduces feed intake (Utley et al., 1970), which results in lower production. However, water restriction also tends to increase apparent digestibility and nitrogen retention. Water requirement is influenced by several factors, including rate and composition of gain, pregnancy, lactation, activity, type of diet, feed intake, and environmental temperature (NRC, 2000).

Satiety. Satiety, or the condition of being full, is driven by need, so lactating females need more than growing young animals. In turn, growing young animals need more than healthy adults (Van Soest, 1994).

Environment. Adaptations include physiological changes in basal metabolism, respiration rate, and distribution of blood flow to skin and lungs, feed and water consumption, passage rate of feed through the digestive system, hair coat, and body composition (NRC, 2000). It was also noted animals differ greatly, including genotypically, in their behavioral responses and in their ability to physiologically adapt to the thermal environment. Feed intake has been shown to increase to a point as the temperature falls below the thermoneutral zone and decrease to a point above that zone (NRC, 2000) The primary environmental effects on voluntary intake of cattle occur at temperatures greater than 25 degrees C and less than 15 degrees C and by exposure to wind, storms and mud. It is suggested the effects of environmental conditions on intake vary with changes in the animal's critical temperature. Critical temperature is the point the animal must increase or decrease heat production to maintain a normal body temperature. This temperature is a function of age, body mass, hide and external fat thickness, hair coat density and depth, and dietary energy density (NRC, 1987). Osuji (1974) demonstrated energy expenditure and nutrient requirements are markedly affected by the grazing animal's environment.

Supplementation. Generally, it has been found addition of readily available carbohydrates to a roughage diet decreases voluntary intake. Conversely, addition of protein supplements to low-quality roughage diets increases voluntary intake and digestibility (Allison, 1985).

Other physiological status factors affecting intake. Dietary nutrient deficiencies, particularly protein, can decrease feed intake (NRC, 2000). Depression in intake is associated with crude protein concentrations below 7 percent. This level is below the nitrogen requirement of ruminal bacteria, even supplemented by recycled urea, resulting in digestibility depression. The animal's restriction of intake is consistent with the conservation of nitrogen (Van Soest, 1994). Forage intake responses to protein are most typical when forage crude protein is less than 6 to 8 percent (NRC, 1987)

In ruminants acetate and propionate appear to play a role in the control of meal size (NRC, 1987). Acetate and propionate both depress feed intake, but different receptors are thought to exist for each volatile fatty acid (VFA) in the ruminal area. The role of VFA's in food intake control did not involve blood concentration changes.

Previous diet is a key factor in determining subsequent eating patterns (NRC, 1987). Variation in direct intake measurements appears to be largely due to variation in individual animal ability to consume forage. Intake of coarse forages, however high in digestibility, is still limited by their cell wall content. Poor quality forage restricts individual expression, and therefore variability in intake is largest for high-quality forages (Van Soest, 1994).

Plant factors affecting intake

The two major factors influencing intake by grazing cattle are quantity and quality of available forage. Quantity is the first limiting factor. As quantity declines, the amount of intake per grazing bite declines. In addition, as the grazing pressure increases and/or the plants mature, the animal is forced to consume plant parts with a slower rate and extent of digestion (NRC, 1987). Although somewhat interdependent, intake and digestibility are separate parameters of forage quality. Intake depends on the structural volume, and therefore the cell wall content, and digestibility depends on both cell wall content and its digestion availability as determined by lignification and other factors (Van Soest, 1994)

Plant maturity/quality

Legumes are generally high in lignin but are consumed at a high intake, and grasses are usually lower than legumes in lignin content but higher in cell wall content. The positive association between lignin and intake is largely a result of the legume-grass comparison. The relation of various forage components to intake ultimately depends on their association with plant structure. Thus, cellulose is more closely associated with intake than digestibility, and lignin is more closely associated with digestibility than intake (Van Soest, 1994). The plant cell wall is the most consistent fraction related to intake because the cell wall contains the entire structural substance of the plant within which all other components are contained. Lamb et al. (2002) found steers' voluntary organic matter intake was higher for less mature plant fractions. In addition, the less mature fractions were higher in organic matter digestibility.

Cell wall density is related to lignification. This leads to potential contradiction of the bulk theory of fill limitation since plant cell walls are not of uniform density and mature lignified walls are much denser than immature ones. Both forage density and plant cell wall density have lower correlations with voluntary intake (r = 0.3-0.4) than does cell wall content (r = 0.76). Immature, voluminous, thin walled cells are not only more digestible, they are also more likely to collapse during rumination or pelleting than thicker-walled, denser, more lignified cells. Thus, the bulkiness may be offset by higher digestibility and volume decrease after grinding (Van Soest, 1994).

When diet quality does become limiting, NDF is the most important dietary component (NRC, 1987). Both intake and digestibility of a given plant species decline with advancing maturity. Variation of forage intake with increasing maturity is probably highly species-oriented. In most cases, intake decreases with plant growth, but rate of decline has not been consistent (Cordova et al., 1978).

Acceptability of forage plants can strongly influence intake of grazing animals, with intakes of broad leafed plants differing from grasses (Allison, 1985). Johnson et al. (1998) observed late season decreases in crude protein, in vitro organic matter disappearance, and rate and extent of in situ NDF disappearance and increases in dietary ADF, NDF, and lag time of in situ NDF disappearance for beef steers grazing in western North Dakota.

Stem vs. leaves

Hay stems are more resistant than leaves to degradation in the rumen (Welch, 1982). Stems were more brittle; however, they appeared similar to their initial form, indicating exposure to the rumen environment alone was not sufficient to reduce particle size small enough to pass through the reticulo-omasal orifice. Lamb et al. (2002) found similar organic matter intake of the leaf or stem hay fractions within stage of maturity.

Moisture

Moisture level may affect selectivity of grazing. More succulent plants will usually be grazed in preference to drier, more mature plants (Allison, 1985). The relationship between water content of forages and intake, therefore, may be a function of structural volume if the plant water is contained within the cell wall structure. The addition of water by itself to the rumen has little effect upon intake because it is largely absorbed and removed (Allison, 1985). However, Van Soest (1982) believes water retention by the sponge effect of coarse structural components of ingested forage can have an inhibitory effect on intake. Greater consumption of leaf material versus stems in legumes and grasses was associated with shorter retention time in the rumen and not by differences in digestibility (Allison, 1985)

Stocking rate/availability

Quantity of forage available can affect feed intake for grazing cattle (NRC, 2000). Several researchers cited in a review by Allison (1985) have demonstrated yield and physical presentation of available forage to grazing animals may have marked effects on feed intake under intensive pasture conditions, but may have no measurable effect on extensively managed pastures. Data from research conducted by Allison et al. (1982) indicated a possibility for a two-fold increase in forage harvest efficiency by grazing cattle as grazing pressure increased. With increasing grazing intensity, livestock have less chance to graze selectively because of increased removal rate of preferred species and plant parts (Allison, 1985).

Processing

Intake is improved most with processing where roughage is a major constituent, and the impact increases with increasing concentrations of plant cell wall and with alkali, ammoniation, or other treatments increasing the potential for cell wall digestion. Increasing the rate of passage of indigestible material can improve intake of forages high in cell wall content by up to 50 percent. Generally, however, intake is reduced if grains are processed and if digestibility is increased (NRC, 1987).

The reduction in particle size and the collapsing of the cell wall structure increase the density of the feed. The greater density will allow faster rates of ingestion and less rumen volume.

Finer particles induce less rumination and have faster passage rates, thus the penalty on digestibility resulting from the passage and loss of potentially digestible fiber may offset the advantage of increased intakes of some high-cell-wall forages (Van Soest, 1994). Rate of particle size breakdown is probably related to animal size, because rumination time per gram of NDF decreases exponentially with BW (Welch, 1982).

Intake control mechanisms

The NRC (1987) classifies factors influencing the control of food intake into two categories: (1) factors causing feeding behavior to change independent of body stores and (2) factors sensitive to the size of the adipose mass.

The primary site responsible for the integrated control of feed intake and energy balance is the central nervous system, although the specific mechanisms involved are not well understood (NRC, 1987).The hypothalamus is directly and indirectly involved in the systems control and body energy content variations. The center controlling energy balance in the brain is classically the ventromedial nuclear region on the hypothalamus (VMH). Lesions of the hypothalamus produce a number of effects related to the control of feed intake in both ruminant and monogastric animals. Olfactory cues can influence whether or not a meal will be initiated, and taste may affect the length of that meal. It does appear species variability exists with regard to taste preferences (NRC, 1987).

Consumption of less-digestible, low-energy (often high fiber) diets is controlled by physical factors such as ruminal fill and digesta passage, whereas consumption of highly digestible, high-energy (often low-fiber, high-concentrate) diets is controlled by the animal’s energy demands and by metabolic factors (NRC, 1987). Ketelaars and Tolkamp (1992) argued against this theory, suggesting intake had more to do with efficiency of oxygen utilization. The intake models given in the NRC (2000) are observational in nature.

Ruminant feeding behavior can also be influenced by changes in osmolarity of body fluids. Increases in rumen fluid osmolarity during rapid eating of large meals can produce hypertonicity of body fluids and result in dramatic circulatory and renal changes (NRC, 1987). Waldo (1969) theorized with certain forages, intake could be limited by rumen capacity and rate at which undigested residues left the reticulorumen.

The primary factors controlling intake in beef cattle are those related to dietary effects (distension of the rumen wall, rumen pH and acetate concentration, and hepatic uptake of propionate) and metabolic factors mediated by the central nervous system, including size of adipose mass and demand for satisfying maintenance and production functions (NRC, 1987). The ecological niche occupied by grazing ruminants requires processing of large amounts of fibrous feeds. Sensing and maintaining rumen fill is an important trait for occupying that niche (Fisher, 2002). Ansotegui et al. (1991) suggested forage intake by suckling calves may be under metabolic control rather than being limited solely by rumen fill. Animals tend to achieve and maintain a particular percent body fat. This metabolic control is referred to as a lipostatic feedback (Fisher, 2002).

Fill mechanism/rumen size

Evidence suggests rumen distension may be detected by tension receptors with varying neural adaptation times thought to exist in the ruminant stomach (NRC, 1987). In a review by Allison (1985) evidence cites voluntary intake is limited by capacity of the reticulorumen and by rate of disappearance of digesta from this organ in predominantly forage diets. When ruminants are offered roughages such as hay and dried grass, evidence exists cattle and sheep eat to a constant rumen fill (Allison, 1985).

A ruminant’s digestive process is divided into digestion rate, digestion lag, potential extent of digestion, and passage rate (Mertens, 1977). Digestion rate is directly related to apparent extent of digestion. Digestion lag is inversely related to apparent extent of digestion. The potential extent of digestion is directly related to apparent extent of digestion and is influenced primarily by plant fiber composition. Passage rate essentially competes with rate of digestion for fiber particles as they pass through the rumen; thus, it is inversely related to the apparent extent of digestion. Passage rate is associated with feed intake level and particle size, although other factors (ex. diet type and animal physiology) may be important.

Van Soest (1994) discusses four physical models of fill, including rumen fill is limiting; lower tract fill and fecal output are limiting; slow rate of digestion at any site limits intake; and rumination rate reduces volume and limits intake. Digestion and passage are two ways rumen fill is alleviated. While digestion rate has been directly related to intake, the mathematical logic of modeling requires integration of the digestion rate with passage rate to estimate the net decrease in amount of rumen ingesta (Van Soest, 1994). Evidence fill limits intake is also supplied by the increase in intake obtained by feeding ground or pelleted forage diets. Grinding and pelleting increase feed density and rate of passage (Van Soest, 1994). The exact mechanism limiting intake in response to fill is not known. Intake may respond to discomfort or the humoral intake-regulating factor (Van Soest, 1994)

Forage intake is usually considered less than optimal, especially with lower quality forages where fibrous bulk is considered the limiting factor. Whether this suboptimal intake is due to plant cell wall content is open to doubt. Possibly the effect attributed to cell wall content is due to an interaction among fill, rumen stretch, time available for eating, and energy density, which can be independent from cell wall content (Van Soest, 1994). Fill's effect on voluntary dry matter intake (VDMI) gradually diminishes as digestibility increases (Allen, 1996). VDMI is limited by fill to a greater extent for forages with low digestibility and high fiber contents. Response to inert fill inserted into the reticulorumen depends on the energy requirement of the animal, the caloric density and filling effect of the diet, the capacity of the reticulorumen, and the ability of the animal to alter flow from the reticulorumen (Allen, 1996). Balloons added to the reticulum may cause a further increase in fill by decreasing flow of particulate matter from the reticulorumen (Allen, 1996).

A major limitation of the various intake models is the assumption of a threshold level of fill weight in the reticulorumen limiting VDMI; this threshold has been implemented as a linear function of body weight. Although distention in the reticulorumen is an important factor affecting VDMI, prediction of VDMI using a threshold fill alone will result in an over prediction of VDMI for high-quality forages, and it is clear other mechanisms must be accounted for (Allen, 1996). When physical limits to intake exist, displacement of reticulorumen contents by inert fill should result in a greater decrease in VDMI for forages with lower fill factors as a percentage of DM, such as alfalfa hay compared with orchardgrass hay (Allen, 1996). Based on the observation that pelleted low-quality, high-fiber forages increase intake and fecal output, Mertens (1994) suggested reticulorumen distension, not flow capacity of undigested feed residues through the abomasum or intestines, limits intake. Both weight and volume of reticulorumen contents affect fill because tension receptors are stimulated by their combined effects (Allen, 1996).

Passage rate

Welch (1982) defined rumination as the regurgitation of fibrous ingesta from the rumen to the mouth, remastication and reinsalivation, followed by swallowing and returning of the material to the rumen. Welch (1982) inhibited rumination in fistulated Jersey steers by placing a fibrous mass in the area of the cardia to determine the effects on long-term rumination and hay intake. Welch was unable to prove prevention of rumination limits intake, but did show rumination and intake were closely related.

Diet digestibility, and thus rate of passage, is reduced if the nitrogen requirements of rumen bacteria are not met (Van Soest, 1982). Diet protein solubility and degradability influence availability to meet microbial nitrogen needs. Thus, the level of nitrogen needed to support the maximum rate of passage would be expected to vary with carbohydrate digestibility in the rumen (NRC, 1987). Feeding frequency affects rate of ingesta passage (NRC, 1987).

NDF content of forages is the most consistent feed component associated with intake. The negative association has usually been interpreted as fill effect. Cell wall volume, however, is less well related to intake than is cell wall (NDF) contents. Time spent ruminating high-NDF forages becomes a time constraint because net ruminating time competes with eating time. Time is more apt to become an intake limiter in low-quality or sparse pastures; therefore, bite size and plant morphology become factors here (Van Soest, 1994).

Differences in fragility exist among forages and must be accounted for in models predicting flow of digesta from the reticulorumen (Allen, 1996). Flow must depend on the quantity of particles eligible to pass from the reticulorumen that are in close proximity to the reticulo-omasal orifice at the second phase of reticular contraction (Allen and Mertens, 1988), which is clearly dependent on particle density.

Particle size reduction is the limiting process in clearing of indigestible fibers from the rumen and rumination plays a major role in this process (Welch, 1982). Particle size reduction is necessary for coarse roughages to pass from the rumen, making the relative importance of microbial activity versus physical breakdown of rumen digesta important.

Particle density

Retention time in the rumen is related to particle density (Allen, 1996). Particle density is determined by the retention of carbon dioxide and methane produced by particle-associated microbes. As fermentation proceeds, potentially fermentable OM diminishes, resulting in a lower rate of gas production and an increase in density (Allen, 1996). Particle density is a function of the potentially fermentable fiber fraction and its fermentation rate(Jung and Allen, 1995).

Allen (1996) proposed a positive relationship between the fraction indigestible over time and particle density. Grass particles may be buoyant for a greater length of time as gas production from fermentation of NDF is extended because of the slower rate of fermentation and greater potentially digestible fraction.

No model adjusts fractional rate of small particle passage or rate of breakdown of large particles for level of DMI. Accuracy of VDMI prediction should increase by inclusion of this mechanism for particle flow from the reticulorumen. Factors affecting particle fragility need to be elucidated and included in models to predict VDMI (Allen, 1996).

Digestibility

The physical need of digesta flow to offset the filling effect of feed ingestion presumes the escape of potentially digestible matter in feces. The sequence of ruminant digestion suggests substances escaping both rumen and lower tract digestion will be those exhibiting the slowest digestion rates. Escape from any digestion compartment is a function of the competitive rates of digestion and passage (Van Soest, 1994).

While it is generally accepted digestibility is depressed as intake increases, the reasons for the variation in the degree of depression are not well understood (Van Soest, 1994). Digestibility depression is a function of the competition between digestion and passage, and it has the greatest effect on the slowest-digesting fractions in the plant cell wall. Digestibility depression is inversely related to lignification and to the rate of digestion. The more digestible the cell wall content, the greater the potential for digestibility depression through the effect of intake level, physical form, passage or concentrate addition (Van Soest, 1994).

Legumes have lower digestibility depressions than most grass forages, and those forages with the highest cell wall content do not necessarily have the greatest amount of digestible cell wall content. As forages mature, the increase in cell wall content is offset by a decline in digestibility through associated lignification (Van Soest, 1994). Rate of fermentation affects digestibility depression. It changes when rumen pH changes or a starch substrate is present to compete. Rate of fermentation depends on intrinsic properties of the cell wall carbohydrates rather than lignification (Van Soest, 1994).

Predicting intake

The most successful approach has been to recognize environmental factors affecting food intake and integrate them into a system that also considers the physiological state of the animal (Van Soest, 1994). Distension feedback suggests processing forage to speed its flow throughout the rumen should increase intake and should be most effective with forages of lower quality and slowest rates of passage from the rumen (Fisher, 2002). With forage diets of moderate energy content, feed intake should increase with an increase in diet digestibility as a result of increased digestion and passage. If metabolic feedbacks exist, the addition of inert bulk to the rumen should reduce intake but may be partially compensated for by a higher tolerated level of fill (Fisher, 2002).

Ketelaars and Tolkamp (1996) proposed intake is simply regulated to maximize efficiency of oxygen consumption; the costs and benefits of feed intake are considered and feed intake is regulated to maximize the yield of net energy per liter of oxygen consumed. Rumen fill is viewed as a consequence of animal feeding behavior rather than having a regulatory effect on intake. Ketelaars and Tolkamp (1992) hypothesized feed intake is adjusted by the animal to maximize efficiency of oxygen utilization. They observed indigestible matter intake and reticulorumen fill starts to drop off once feed digestibility is greater than 70%, whereas OMI and digestible OMI continue to rise. However, this observation supports a breakpoint at which limitation to VDMI resulting from physical fill is replaced by limitation resulting from satisfaction of energy requirements; identification of other factors limiting VDMI does not exclude physical limitations (Allen, 1996).

Animal unit (AU)

The term, animal unit, is commonly utilized in grazing management strategies. In Scarnecchia's (1985) review, the term, "cow-day," was a precursor to the animal unit day and mentioned as early as 1907 by U.S. Forest Service grazing inspectors. Currently many definitions exist for the term, but they all have one common theme – define forage intake on the basis of a standard animal.

Terms associated with an AU include animal unit day (AUD), animal unit month (AUM) and animal unit year (AUY). An AUD defines the daily forage intake, an AUM measures the amount of forage required to sustain the standard animal for one month, and an AUY is the amount required to sustain the standard animal for one year. Across popular publications (Table 1), inconsistencies exist. Many of the publications agree the standard animal consumes approximately 2.6% of their BW on an air-dry basis.

Scarnecchia and Kothmann (1982) defined the AU to be a unit of animal demand equivalent to approximately 11.8 kg DM/day. An animal with a demand rate more or less than 11.8 kg DM/day will have an AU equivalent which is a proportionate fraction or multiple of one AU. An AUM would then be defined as 354 kg DM and an AUY would be equivalent to 1,926 kg.

Scarnecchia (1985) stated an AU definition does not include herbage and environmental characteristics and is a function of only animal factors such as metabolic size, gestation or lactation. Scarnecchia (1985) also argued the AU concept is best applied within species and should be calculated based only on animal related factors, including weight, lactation, gestation, and other animal factors affecting animal demand.

Defining the standard animal

Vallentine (1965) proposed an AU be defined as a mature, 454 kg dry cow in maintenance or gestation, or its equivalent. An AUM would then be the forage or feed necessary to support this AU for 30 d. This definition does not account for forage intake affected by lactation and the age of calf. An AU based on live weight alone does not distinguish between physiological stages that may affect forage intake.

Much of the literature expresses a standard age and phase of livestock production as the basis for an AU definition. An AU based on ad lib consumption is only a quantitative measure of forage. Even an AU of feed based on digestible energy does not consider other quality factors such as proteins, minerals, or vitamins.

In popular and extension literature, variations of the AU definition are abundant. 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 3-4 months postpartum, with an AUM being the amount of forage required to sustain one AU for one month. This value was given as 308 kg of forage (DM basis; 340-354 kg air dry).

Redfearn and Bidwell (2003) described an AU as a cow with calf, no age of calf given. They agree with preceding literature that an AUD is 11.8 kg (DM) of forage and an AUM is 354 kg of forage (air-dry). Reynolds et al. (2001) defines an AU as 0.10 $\times$45 kg of animal weight, but then goes on to use the Waller et al. (1986) definition for one AU, but defines a 454 kg, non-lactating cow as only 0.9 AU. Reynolds also assigns several AU values to various classes of cattle, largely based on age and sex, including 0.50 AU for yearling cattle, ages 7 to 12 mo; and 0.75 AU for yearling cattle, ages 12 to 17 mo.

Some definitions do make allowances for physiological changes to the animal, including milk production (Waller et al., 1986) and weight of animal (Waller et al., 1986; Ohlenbusch and Watson, 1994). The Society for Range Management (1989) and Iowa State University (1998) consider an AU to be one mature cow of approx. 454 kg, either dry or with calf up to 6 mo, or their equivalent, based on a standardized amount of forage consumed, 11.8 kg of forage a day (DM basis). Lyons and Machen (2001) consider an AU as a mature, 454 kg cow and her calf (age of calf not given), representing an average daily forage intake of 11.8 kg (DM) or 2.6% of BW, recommending stocking rate be based more on potential forage intake than on animal numbers. Gerrish and Roberts (1999) define an AU as a 499 kg cow without calf, 1.4 yearling cattle or 5 dry ewes, with an AUM considered 454 kg of forage dry matter. Table 1 brings together AU definitions from extension and other peer reviewed publications.

Estimating forage intake from a cow's weight can cause some error if the cow's body condition score (BCS) is not considered. Body condition score is closely related to an animal's body fat and energy reserves. Few producers weigh cows to monitor their feeding program, instead observing BCS as a management tool (NRC, 2001). Lyons and Machen (2001) recommend using an animal's BW at BCS 5 to standardize calculations and estimate forage intake. This standard would allow calculations to be estimated relative to intake potential as animal size (gut capacity) increases (or decreases). An AU is a measure of intake, but one must consider what causes an animal to consume the amount it does. Voluntary intake is ultimately a psychological phenomenon, which is the primary difficulty in predicting voluntary intake in ruminants (Illius and Jessop, 1996).

Variations of the AU definition exist, but many concentrate around a value of 2.6% BW intake per day. This project will look at the effects of lactation and growth compared to a control animal.

On the whole, the AU concept is valid or it wouldn't have been used for the last 100 years. While it is a good starting point, the AU concept calls for continual refinement and improvement.

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Literature Review Table 1. Definitions of the animal unit (AU) found in popular, extension, and other peer-reviewed publications.

Citation	Standard Animal	Amount of Forage by 1 AU	Comments
Alberta Agriculture and Food, 2007	one mature 454 kg cow and her suckling calf	11.8 kg (DM)/day	9.1 kg (DM)/ day for the cow; 2.7 kg (DM)/day for the calf.
Forage and Grazing Terminology Committee, 1991	Mature, non-lactating bovine weighing 500 kg and fed at a maintenance level, or the equivalent, expressed as $(\text{weight})^{0.75}$,in other kinds or classes of animals.	8 kg (DM)/day (NRC, 1984)	
Gerrish and Roberts, 1999	499 kg cow without calf or 1.4 yearling cattle	15 kg (DM)/day or 454 kg (DM)/mo	
Iowa State University, 1998	mature cow of approximately 454 kg, either dry or w/ calf up to 6 mo old	11.8 kg (DM)/day	
Ohlenbusch and Watson, 1994	454 kg mature cow of above average milking ability with a calf less than 3-4 months old, weaned at 181 kg	approximately 340 kg of air dry forage/mo	Cites an equivalent for growing cattle=((weight on grass + weight off grass)/2)/1000
Pratt and Rasmussen, 2001	454 kg cow with calf	363 kg (DM)/mo	Also suggests using 2.667% BW
Redfearn and Bidwell, 2003	454 kg cow with calf	11.8 kg of dry forage or 354 kg of dry forage/mo	Recommendation for 408 kg BW or less: (BW+45)/454 for 499 kg or more: (BW-45)/454
Reynolds et al., 2000	.001×BW or 454 kg cow and calf (spring calving, above average milking ability, first 3 to 4 months postpartum)		
Scarnecchia and Kothmann, 1982		unit of animal demand equal to 12 kg DM/day	

Literature Review Table 1, page 2. Definitions of the animal unit (AU) found in popular, extension, and other peer-reviewed publications.

Citation	Standard Animal	Amount of Forage by 1 AU	Comments
Sedivec 1996 (North Dakota)	454 kg beef cow with calf		499 kg cow/calf=1.07 au; 544 kg cow/calf=1.13 au; 590 kg cow/calf=1.19 au; 635 kg cow/calf=1.25 au;
SRM, 1989	mature cow of approximately 454 kg, either dry or with calf up to six months of age, or their equivalent, based on a standardized amount of forage consumed	11.8 kg/day	
USDA NRCS, 2003	mature cow of approximately 454 kg, either dry or w/ calf up to 6 mo old or their equivalent	11.8 kg (DM) or 13.6 kg (as-fed)/day	Also states: Dry cow = 0.92 AUYearling = 0.6 AU
Vallentine, 1965	454 kg dry cow in maintenance, gestation or its equivalent	540 therms of DE or 122 kg TDN	does account for early lactation (1.25 au)
Waller et al., 1986	454 kg cow of above average milking ability with a calf less than 3-4 months of age	308 kg (DM)/mo or 340-354 kg as-fed	
White and Troxel	non-lactating 454 kg cow in the last third of pregnancy	8.9 kg of 53.6% digestible forage daily	Uses the term stock-unit-equivalent (SUE), instead of AU.

Estimating Livestock Forage Demand: Defining the Animal Unit

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ABSTRACT

The objective of this experiment was to evaluate the effect of a beef animal's physiological status on forage intake. The experiment was repeated over two years with six replications of three treatments per year: cow-calf pair (CC; BW = 629 kg), dry cow (DC; BW = 503 kg), and yearling steer (S; BW = 305 kg). The cow and calf were treated as one unit, with cow BW and calf BW comprising CC BW. Calves were approximately 42 d of age and weighing 73 kg at the start of each year. Animals were housed in individual pens and fed high quality (11.6% CP) meadow hay *ad libitum* daily. Daily diet samples were composited by week and analyzed for dry matter (DM), organic matter (OM), *in* vitro dry matter disappearance (IVDMD), neutral detergent fiber (NDF), and undegradable intake protein (UIP). Refusals were collected, composited by week per pen, and analyzed for DM, OM, IVDMD, and NDF. Refusals were also composited for each year by pen and evaluated for UIP. Data was analyzed using the MIXED procedure of SAS. The cow-calf pair had the largest DMI, followed by the dry cow, and then the yearling steer ($P < 0.01$). A year × treatment effect was present. In year 1, cow-calf pairs had the highest intake as %BW, followed by dry cows, and then yearling steers ($P < 0.01$). In year 2, DMI as % BW was different between the cow-calf pairs and dry cows ($P < 0.01$). Cow-calf pairs and yearling steers were the same ($P = 0.31$), as were the dry cows and yearling steers ($P = 0.12$). Dry matter intake as % metabolic BW was the same for cow-calf pairs and dry cows ($P = 0.51$). Results indicate intake differences among cattle of different physiological states or classes should be considered when calculating forage demand for stocking rate or feeding purposes.

Keywords: animal unit, forage intake, beef cattle

INTRODUCTION

Grazing is the basis for most beef cattle production systems. Careful management is needed to sustainably utilize the forage resource ,and matching available forage to the animal's requirements is necessary for optimal beef production. The term, animal unit (AU) is widely used in grazing management strategies. Various definitions for the terms AU, animal unit day (AUD), animal unit month (AUM), and animal unit year (AUY) exist; but they all have one common theme – define forage intake on the basis of a standard animal. General consensus is the standard grazing animal consumes about 2.6% BW (DM basis) daily.

Scarnecchia and Kothmann (1982) defined the AU as a unit of animal demand equivalent to approximately 11.8 kg DM/day. An animal with a demand rate more or less than 11.8 kg DM/day will have an AU equivalent which is a proportionate fraction or multiple of one AU. An AUM would then be defined as 354 kg DM and an AUY equal to 4,245 kg.

Scarnecchia (1985) suggested the AU concept should be calculated based only on animal related factors, including weight, lactation, gestation, and other factors which might affect animal demand. In a cross-section of AU definitions (see Literature Review, Table 1), variation occurs when describing the standard animal.

In popular and extension publications, deviations of the AU definition occur. 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 three to four months postpartum. This AUM forage value was given as 308 kg of forage dry matter (10.3 kg = 1 AUD; 340-354 kg air dry). 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) defines an AU as 0.10 $\times$45.4 kg of animal weight; then uses the Waller et al. (1986) definition for one AU, but equates a 454 kg cow, non-lactating, to 0.9 AU. Reynolds et al. (2000) also assigns 0.50 AU for yearling cattle, age 7 to 12 mo; and 0.75 for yearling cattle, ages 12 to 17 mo. The Society for Range Management (1989) and Iowa State University (1998) consider an AU one mature cow of about 454 kg, either dry or with calf up to 6 mo, or their equivalent, based on a standardized amount of forage consumed, 11.8 kg of forage a day (DM basis). Gerrish and Roberts (1999) define an AU as a 499 kg cow without calf, 1.4 yearling cattle or 5 non-lactating ewes, with an AUM considered roughly 454 kg of forage dry matter.

Allison (1985) listed body size, physiological status, body condition, supplementation, forage preference, forage availability, and grazing systems as factors affecting intake. The factor accounted for in most animal unit definitions is body size, with physiological status being the most erratic factor in defining an animal unit. We hypothesized physiological status would affect DMI; therefore, the objective of this experiment was to evaluate the effect of a beef animal's physiological state on forage intake and how it compares to standard AU intake values.

MATERIALS AND METHODS

Facilities. This project was replicated over two years, with year 1 located at the University of Nebraska Gudmundsen Sandhills Laboratory (GSL), near Whitman, NE (elevation 1,073 m, lat 42°05' N, long 101°26' W) and year 2 at the University of Nebraska West Central Research and Extension Center (WCREC; elevation 696 m, lat 41°08' N, long 100°77' W), North Platte, NE. Temperature and precipitation data for each location and year are shown in Table 1.

Animals, Design, and Treatments. All animal procedures were approved by the University of Nebraska Institutional Animal Care and Use Committee. The experiment was repeated over two years with six replications of three treatments each year: cow-calf pair (**CC**; BW = 649 kg; $BW^{0.75}$ = 105 kg), dry cow (**DC**; BW = 508 kg; $BW^{0.75}$ = 88 kg), and yearling steer (**S**; BW = 310 kg; $BW^{0.75}$ = 61 kg). Cow-calf pair BW includes cow BW and calf BW. Pens in year 1 were approximately 0.33 hectare in size, with pens in year 2 approximately 914 m^2. A feeding trial to determine intake was conducted in each of year 1 and year 2. The feeding trial was for 13 weeks in year 1 and 9 weeks in year 2. The first two weeks of year 1 and the first week of year 2 were considered an adaptation period and not included in data analysis. The sixth week

(July 8, 2001 to July 15, 2001) of year 1 was also removed from analysis due to excessive precipitation resulting in wet feed (hay) and depressed intake. The cow and calf were treated as one unit, with calf age averaging 42 d and weighing 73 kg at the start of the experiment each year. Animals were housed in 18 individual pens with water and salt provided *ad libitum*. Mature females were spayed two weeks prior to the trial.

Diet. Animals were offered hay (11.5% CP, 53.1% IVDMD) harvested from sub-irrigated meadows at GSL. Hay was fed in bunks. Tables 2 and 3 provide the analysis of hay supplied. Hay was weighed and offered daily in amounts to allow *ad libitum* intake. The target diet offered was approximately 3% of BW. Dry matter was determined from samples collected daily and composited within week. Refusals from the bunk in each pen were weighed and dry matter determined weekly in year 1 and daily in year 2. In year 2, refusals were then composited by week. In year 1, hay from round bales was processed to decrease stem length for easier manipulation during feeding. From the 11th week to the end of year 1 and in year 2, hay was from the same source but packaged in square bales.

Data Collection. At the beginning, middle, and end of each experiment, all animals were weighed for three consecutive days. Lactating and dry cow BW measured at the beginning of each year were used in analysis. Yearling steer and calf BW used were the mean BW between beginning and final BW measured. Cow-calf pair BW comprises cow BW and calf BW. Metabolic body weight was calculated as $BW^{0.75}$. In addition, milk production was measured each time for the CC using a 12-hour weigh-suckle-weigh procedure. Calves were separated from their dams for approximately 12 hours, combined and allowed to nurse until completed, then re-sorted and separated for approximately 12 hours. Calves were then weighed, allowed to nurse until done, and re-weighed. Twenty-four hour milk production was determined by doubling the 12-hour milk production.

Diet and refusal samples were dried in a forced air oven for 48 hr at 60°C. Daily diet and refusal samples were composited by week. All samples were then ground to pass through a 2-mm screen in a Wiley mill, with a subsample ground to pass through a 1-mm screen.

Sample Analysis. Diet and refusal samples were analyzed for DM, OM, and CP by standard methods (AOAC, 1996). In vitro DMD, NDF, and undegradable intake protein (UIP) were also analyzed. Ruminally fistulated cows were maintained on a diet of meadow hay, providing inoculum for IVDMD, as well as *in situ* incubation. *In vitro* dry matter disappearance was determined using the Tilley and Terry (1963) method modified by the addition of 1 g/L of urea to McDougall's buffer (Weiss, 1994). The IVDMD was then adjusted to *in vivo* digestibility as described by Geisert et al. (2007).

For NDF analyses, sample bags were filled with 0.5 g of diet or refusal sample ground to pass through a 1 mm screen. Bags were heat sealed and placed in a bag suspender in neutral detergent solution in the fiber analyzer (Ankom Inc., Fairport, NY). Samples were agitated for 70 minutes and rinsed three times with boiling distilled water. Bags were then placed in a drying oven at 60° C and allowed to dry overnight before weighing.

In situ incubations were replicated using two bags per sample per ruminally fistulated cow, providing 4 bags per sample. Dacron bags (5×10 cm; Ankom Inc., Fairport, NY) with an average pore size of 50 μM were filled with 1.25 g of dried composited hay and refusal samples ground to pass through a 2 mm screen. Incubation times included 0 hours and 27 hours. Following incubation, bags were hand washed (39°C) for five cycles consisting of agitation and rinsing. Bags were then refluxed in a neutral detergent solution using a fiber analyzer (Ankom Inc., Fairport, NY) to remove microbial contamination (Mass et al., 1999), and dried for 48 hours at 60°C. Bags were weighed and then air-equilibrated, re-weighed, and residues were analyzed for N by combustion (AOAC, 1996) using a Leco FP-528 nitrogen analyzer (St. Joseph, MI).

Statistical analysis. Average daily intake during each week of the experiment was analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). The model included the effects of treatment as a fixed effect and year and treatment × year interaction as random effects. Individual animal or cow/calf pair was used as the experimental unit, with $P < 0.05$ considered significant. Due to the different number of weeks each year, week was not included in the model.

RESULTS

Hay quality for both years is shown in Tables 2 and 3. Yearling and calf BW change during each trial is shown in Table 4. Milk production data are presented in Table 5. Although not a grazing study, hay quality was similar to diet quality in previous studies utilizing Sandhills range and meadow (Hollingsworth-Jenkins, 1994; Geisert et al., 2008). In addition, yearling steer and calf performance was similar to grazing animals (Jordon et al., 1999; Stalker et al., 2006).

Intakes were analyzed on a DM basis, OM basis, IVDMD basis, and NDF basis. Intakes were expressed three ways: actual intake in kg, intake as % BW, and intake as % metabolic body weight (MBW). To determine significance, $P< 0.05$ was used. There was a year × treatment effect. Actual cow-calf pair intakes were higher than dry cow and yearling steer intakes both years. When expressed as %MBW, cow-calf pair and dry cow intakes were not different, regardless of year. Dry cow intakes were greater numerically than yearling steer intakes in Year 1; however in Year 2 when expressed as %BW, the yearling steers had higher intakes. For this reason, results are shown with both years averaged (Table 6) and as individual years (Year 1 in Table 7, Year 2 in Table 8).

Body weight and consequently, MBW, were similar within treatment between Year 1 and Year 2 ($P = 0.41$). Averaged across both years (Table 6), CC weight (629 kg) was the heaviest of the three treatments, followed by DC (503 kg) and S (305 kg).

Year 1 and Year 2 intakes combined

Daily DMI. Actual intake was different (*P* < 0.01) among treatments (Table 6). The cow-calf pair consumed over 4 kg more per day than the dry cow (16.2 vs. 11.8 kg, CC vs. DC, respectively) and over 9 kg more per day than yearling steer (16.2 vs. 6.8 kg). Intake as % BW was different (P < 0.01) among treatments (2.58 vs. 2.37 vs. 2.24% BW, CC vs. DC vs. S, respectively). Intake as % MBW was not different (*P* = 0.51) between the cow-calf pair and dry cow (13.80 vs. 13.62% MBW, CC vs. DC, respectively). The yearling steer's intake as % MBW was less than (11.39%, *P* < 0.01) both the cow-calf pair and dry cow.

Daily OM Intake. Actual intake was different among treatments (*P* < 0.01). The cow-calf daily OM intake was 4 kg more than the dry cow (10.7 kg) and 8.5 kg more than the yearling steer (6.2 kg). Organic matter intake as % BW was also different (P < 0.01). Intake as % MBW was not different (*P* = 0.53) between the cow-calf pair and the dry cow (12.49 vs. 12.34% MBW, CC vs. DC, respectively). The yearling steer's OM intake as % MBW was less than (10.33%, *P* < 0.01) both the cow-calf pair and dry cow.

Daily IVDMD Intake. Actual intake and intake as % BW are different among treatments (*P* < 0.01). The cow-calf pair had the largest actual intake (8.6 kg) as well as the largest IVDMD intake as % BW (1.38%) of the three treatments. *In vitro* dry matter digestibility intake as % MBW was not different (P = 0.59) between cow-calf pair and dry cow (7.35 vs. 7.26% MBW, CC vs. DC, respectively). Intake as % MBW was less for the yearling steer (6.10% MBW; *P* < 0.01) than both the cow-calf pair and dry cow's intake.

Daily NDF Intake. Actual intake and intake as % BW were different among treatments (*P* < 0.01). The cow-calf pair had the largest actual NDF intake (10.5 kg) and the largest NDF intake as % BW (1.68%). Neutral detergent fiber intake as % MBW was not different (P = 0.47) between cow-calf pair and dry cow (8.97 vs. 8.84%, CC vs. DC, respectively). As was the case in the other intake measures, the yearling steer's NDF intake as % MBW was less than both the cow-calf pair and dry cow intakes (7.38% MBW; $P < 0.01$).

Year 1 intake

Daily DMI. Actual DM intake and intake as % BW were different ($P < 0.01$, Table 7) among all three treatments. The cow-calf pair exhibited the greatest intakes (18.3 kg, 2.91% BW), followed by the dry cow (13.3 kg, 2.62% BW), and the yearling steer (6.8 kg, 2.27% BW). Dry matter intake as % MBW was not different ($P = 0.42$) between the cow-calf pair and dry cow (15.52 vs. 15.18% MBW, CC vs. DC, respectively). The yearling steer's DMI as % MBW was less than the cow-calf pair and dry cow (11.53% MBW, $P < 0.01$).

Daily OM Intake. Actual OM intake and intake as % BW were different ($P < 0.01$) among treatments. The cow-calf pair exhibited the greatest intakes (16.6 kg, 2.64% BW), followed by the dry cow (12.2 kg, 2.39% BW), and the yearling steer (6.3 kg, 2.07% BW). Organic matter intake as % MBW was not different ($P = 0.44$) between the cow-calf pair and dry cow (14.12 vs. 13.83% MBW, CC vs. DC, respectively). The yearling steer's OMI as % MBW was less than the cow-calf pair and dry cow (10.50% MBW, $P < 0.01$).

Daily IVDMD Intake. Actual IVDMD intake and intake as % BW were different ($P < 0.01$) among treatments. The cow-calf pair exhibited the greatest intakes (9.8 kg, 1.56% BW), followed by the dry cow (7.2 kg, 1.41% BW), and then the yearling steer (3.7 kg, 1.22% BW). *In vitro* dry matter disappearance intake as % MBW was not different ($P = 0.50$) between the cow-calf pair and dry cow (8.40 vs. 8.16% MBW, CC vs. DC, respectively). The yearling steer's IVDMD intake as % MBW was less than the cow-calf pair and dry cow (6.22% MBW, $P < 0.01$).

Daily NDF Intake. Actual NDF intake and intake as % BW were different ($P < 0.01$) among treatments. The cow-calf pair exhibited the greatest actual NDF intake and as a %BW (11.6 kg, 1.85% BW), followed by the dry cow (8.5 kg, 1.67% BW), and then the yearling steer (4.4 kg, 1.44% BW). Neutral detergent fiber intake as % MBW was not different ($P = 0.47$)

between cow-calf pair and dry cow (1.83 vs. 1.58%, CC vs. DC, respectively) and cow-calf pair and steer (9.87 vs. 9.67%, CC vs. S, respectively). Neutral detergent fiber intake as % MBW was less for the yearling steer than the cow-calf pair and dry cow (7.30% MBW, $P < 0.01$).

Year 2 intake

Daily DMI. Actual DMI was different among treatments ($P < 0.01$, Table 8) with the cow-calf pair consuming the most (14.1 kg), followed by the dry cow (10.3 kg), and then the steer (6.8 kg). Numerically, DMI as % BW was highest for the cow-calf pair (2.26% BW), followed by the yearling steer (2.20% BW), and then the dry cow (2.12% BW). However, there was no significant difference between the cow-calf pair and the yearling steer ($P = 0.31$) and between the yearling steer and the dry cow ($P = 0.12$). Dry matter intake as a % BW was different between the cow-calf pair and the dry cow ($P <0.01$). Daily DMI as % MBW was the same ($P = 0.99$) for both the cow-calf pair and dry cow (12.07% MBW). The yearling steer's DMI as % MBW was less than the cow-calf pair and dry cow intake (11.26% MBW, $P < 0.01$).

Daily OM Intake. Actual OM intake was different among treatments ($P < 0.01$) with the cow-calf pair consuming the most (12.7 kg), followed by the dry cow (9.2 kg), and then the steer (6.2 kg). Numerically, OMI as % BW was highest for the cow-calf pair (2.03% BW), followed by the yearling steer (1.99% BW), and then the dry cow (1.90% BW). However, there was no significant difference between the cow-calf pair and the yearling steer ($P = 0.37$) and between the yearling steer and the dry cow ($P = 0.11$). Dry matter intake as a % BW was different between the cow-calf pair and the dry cow ($P <0.01$). Daily OMI as % MBW was the same ($P = 0.99$) for both the cow-calf pair and dry cow (12.07% MBW). The yearling steer's DMI as % MBW was less than the cow-calf pair and dry cow intake (10.85% MBW, $P < 0.01$).

Daily IVDMD Intake. Actual IVDMD intake was different among treatments ($P < 0.01$) with the cow-calf pair consuming the most (7.4 kg), followed by the dry cow (5.4 kg), and then the steer (3.6 kg). Numerically, IVDMD intake as % BW was highest for the cow-calf pair

(1.19% BW), followed by the yearling steer (1.17% BW), and then the dry cow (1.12% BW). However, there was no difference between the cow-calf pair and the yearling steer (*P* = 0.55) and between the yearling steer and the dry cow (*P* = 0.05). Dry matter intake as a % BW was different between the cow-calf pair and the dry cow (*P* <0.01). Daily IVDMD intake as % MBW was the same (*P* = 0.94) for both the cow-calf pair and dry cow (6.35% MBW). The yearling steer's DMI as % MBW was less than the cow-calf pair and dry cow intake (5.98% MBW, *P* < 0.01). *Daily NDF Intake.* Actual NDF intake was different among treatments (*P* < 0.01) with the cow-calf pair consuming the most (9.4 kg), followed by the dry cow (6.8 kg), and then the steer (4.5 kg). Numerically, IVDMD intake as % BW was highest for the cow-calf pair (1.51% BW), followed by the yearling steer (1.46% BW), and then the dry cow (1.40% BW). However, there was no difference between the cow-calf pair and the yearling steer (*P* = 0.26) and between the yearling steer and the dry cow (*P* = 0.17). Dry matter intake as a % BW was different between the cow-calf pair and the dry cow (*P* <0.01). Daily DMI as % MBW was not different (*P* = 0.76) for both the cow-calf pair and dry cow (8.06 vs. 8.00% MBW, CC vs. DC, respectively). The yearling steer's DMI as % MBW was less than the cow-calf pair and dry cow intake (7.47% MBW, *P* < 0.01).

DISCUSSION

Body condition scoring is the preferred method to describe energy reserves (NRC, 1996). Average age, BW at weaning, BCS at weaning, BW at start of trial, and BW at end of trial for lactating and non-lactating cows are given in Table 11. Cow BCS was not measured in this experiment, but BW at the start of the trial were similar to BW measured at weaning the previous year (Table 11). Due to similar BW, it was assumed cattle were the same BCS as well (5.3 for both lactating and non-lactating cows).

In reviewing results in Tables 6, 7 and 8, it appears cow-calf pair and dry cow intakes were greater in Year 1, even though BW and subsequently, MBW, were similar. Several reasons may have led to the difference in intakes. The protocol for collection of refusals may also have affected measured intake. Refusals were removed and weighed on a weekly basis in Year 1, whereas, refusals in Year 2 were removed and weighed daily. Different locations (Year 1 at GSL vs. Year 2 at WCREC) in addition to differences in precipitation and temperature may have also contributed to the intake differences. Temperatures were higher and precipitation was lower in Year 2 (Table 1). Temperatures above 25°C have been shown to depress intake (NRC, 1987). Wind, precipitation, and trampling possibly reduced the amount of refusals collected in Year 1. In addition, bunk design was different between years. In Year 1, bunks were shallow and free-standing. Bunks used in Year 2 were cement, in-line, deeper bunks, and it was observed the calves had more difficulty accessing hay. Although it should be noted, calf BW gain was similar both years.

Actual intake and intake as %BW was consistently highest for the cow-calf pair, although it should be noted the cow-calf pair included both cow and calf BW and intake. According to the NRC (1996), maintenance requirements of lactating cows are approximately 20% higher than those of nonlactating cows, depending on level of milk production. Patterson (2007) reported dry cows removed 28% less forage by grazing than cow-calf pairs during August to November. While calves were observed to eat the hay, no attempt was made to partition hay intake between the cow and calf. Some of the increased intake by CC can be attributed to calf intake. Intake as % MBW was similar for the cow-calf pair and dry cow for all attributes measured.

Data presented in NRC (1987) indicated voluntary intake in mature beef cows is similar to growing cattle when adjusted for the effect of milk production. In year 2 when expressed as % BW, intake was not different between the cow-calf pair and yearling steer. Although actual intake and intake as % MBW was higher for the dry cow compared to the yearling steer in year 1 and year 2, intake as % BW did not follow the same pattern in year 2. While steer intake was numerically higher dry cow intake as % BW (2.20 vs. 2.12% BW, S vs. DC, respectively), the difference was not significant (*P* = 0.12).

Hollingsworth-Jenkins et al. (1995) measured intake of calves similar in age as in the present study and found they consumed from 1.1 to 1.5% of their BW on an OM basis. Lactating cows in the same study consumed 2.0 to 2.6% of their BW on an OM basis. Hollingsworth-Jenkins et al. (1995) also concluded nursing calves grazing native Sandhills summer range select diets higher in rumen degradable protein than their dam. Results from research conducted by Ansotegui et al. (1991) indicated calves nursing low-milk-producing cows consume more forage than those calves nursing high milk-producing cows, but the increased forage consumption by the calf did not imply more forage was necessary for the low milk-producing cow and her calf.

Vanzant et al. (1991) reported OM intake was 16% greater for lactating heifers versus non-lactating controls approximately 26 d after parturition. Lactation prompted an increase in intake and grazing time. When grazing native tallgrass prairie during the winter months and approximately two months before calving, pregnant heifers had greater intakes than control heifers.

Differences in voluntary dry matter intake account for more than 50% of the variation in digestible nutrient consumption by ruminants (Allen, 1996). Consumption of less-digestible, low-energy (often high fiber) diets is controlled by physical factors such as ruminal fill and digesta passage, whereas consumption of highly digestible, high-energy (often low-fiber, high-concentrate) diets is controlled by the animal’s energy demands and by metabolic factors (NRC, 1987).

In a review by Allison (1985), evidence was cited that voluntary intake is limited by reticulorumen capacity and by rate of disappearance of digesta from this organ in predominantly forage diets. When ruminants are offered roughages such as hay and dried grass, evidence exists cattle and sheep eat to a constant rumen fill. Stanley et al. (1993) used late gestating and early lactating crossbred cows to monitor peripaturient changes in DMI, ruminal capacity and digestion and fermentation characteristics. They concluded increased passage rate was one way increased nutrient demand is accommodated in the presence of decreasing ruminal capacity. Patterson et al. (2001) reported decreasing forage intake of bred heifers grazing Sandhills winter range from 2.1% to 1.3% as parturition approached. Loy et al. (2004) demonstrated intake of primiparous heifers declined prior to calving and increased rapidly after parturition. Patterson et al. (2001) hypothesized advancing growth of the fetus and fluids reduce rumen volume prior to calving. Decreased rumen volume coupled with heifers' higher nutritional requirements than mature cows puts them at risk for a negative energy balance during late gestation.

Comparing results of this experiment to predicted intake values given in popular and extension publications, differences are evident. A comparison of selected values is shown in Table 9. Our intake values for a lactating cow are similar to the values offered by ISU (1998), SRM (1989), and Scarnecchia and Kothmann (1982). Many of the other values would over predict forage intake of a dry cow or yearling steer from this experiment. The definition Waller et al. (1986) provided accounts for a lactating cow but resembles the present study's dry cow intake, overestimating for a yearling steer based on our results.

Table 10 compares intake values from the present study with previous research results, including the NRC (1996) model. Lactating cows (Hollingsworth-Jenkins et al., 1995) consumed 2.0 to 2.6% of their BW on an OM basis. In the present study, the cow and calf were treated as one unit, with the intakes for the lactating cows in the previous study being similar to the cow-calf pair (2.3% BW, OM basis).

Dry Cow. The average beginning BW (503 kg) among the dry cows was used in the NRC model. The NRC predicts intake to be 9.5 kg, approximately 1.9% of BW. According to the model, with actual intake at 11.7 kg, it would take 68 d to gain one BCS.

Cow-Calf Pair. The average beginning BW (513 kg) of the lactating cows were used in the NRC model. Cows were considered at 80 d of milk production, 60 mo of age and having a lactation number of three. NRC predicted intake is 13.1 kg, estimating it would take 33 d for a cow to lose one BCS.

The SRM (1989) and ISU (1998) definitions do not measure calf intake until 6 mo. If this standard is used in the model, it is assumed the DMI of 16.4 kg is consumed solely by the cow. At that intake, it would take 1,261 d for a cow to gain 1 BCS. The lactating cows in this study did maintain a constant wt throughout the trial.

Steer. The NRC model does not work well with the steer data in the present study. Average BW of the steers during the trial was used. If the net energy adjuster (Block et al., 2006) is used at 120% when comparing S to the NRC model, intake is over-predicted (8.0 kg predicted vs. 6.8 kg actual), and NRC's predicted ADG from actual intake (0.41 kg) is lower compared to the ADG observed (0.73 kg averaged over both years). If the net energy adjuster is not used (100%), S intake is still over-predicted (7.7 kg predicted vs. 6.8 kg actual) and NRC's predicted ADG based on actual intake (0.19 kg) is even lower than actual ADG observed.

In Table 12, OM intake from the present study is presented along with two modified cow-calf pair intakes. The first modification presents the same intake for the cow-calf pair (14.7 kg) but with the average calf BW (116 kg) subtracted from the total BW, showing an OM intake as 2.9% BW. The second modified intake builds on the first by also subtracting a predicted OM intake from the total OM intake for the cow-calf pair, suggesting an OM intake of 2.6%. The suggested calf OM intake (1.3% BW) comes from Hollingsworth-Jenkins et al. (1995). Both modifications increase OM intake as a %BW above the original OM intake for the cow-calf pair (2.34% BW). Removing the calf from the formula affects intake greatly.

Many estimates of livestock forage demand and AU definitions consider the animal's weight. When determining pasture stocking rates for example, average mature cow weight can vary substantially from herd to herd and it is important to use the appropriate weight value. Results indicate intake differences among cattle of different physiological state or class should be considered when calculating forage demand. This would further increase accuracy of forage demand estimates for stocking rate or feeding purposes.

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TABLES

Table 1. Average monthly temperature and precipitation for Year 1[1] (Gudmundsen Sandhills Laboratory, Whitman, NE) and Year 2[2] (West Central Research and Extension Center, North Platte, NE).

	May	June	July	August
Year 1 average temp, °C	13	18	25	21
Year 2 average temp, °C	13	23	26	n/a[3]
Year 1 total precipitation, cm	3.71	4.85	16.13	1.65
Year 2 total precipitation, cm	3.23	3.28	1.24	n/a[3]

[1] High Plains Regional Climate Center, http://hprcc.unl.edu.

[2] NOAA, 2002.

[3] Year 2 trial did not occur in August.

Table 2. Characteristics of hay fed to cow-calf pairs, dry cows, and yearling steers in Year 1.

	Hay offered	Hay refused	Actual Diet
Dry matter, %	84.1	76.4	--
Organic matter, %	90.5	85.5	91.3
Neutral detergent fiber, %	64.3	70.0	63.8
Crude protein, %	11.6	10.5	11.9
In vitro dry matter digestibility, %	52.6	48.4	53.2
In vivo organic matter digestibility[1], %	56.1	52.4	56.7
Undegradable intake protein, % of CP	41.4	46.4	40.9

[1]Calculated from equation (Geisert et al., 2007): In vivo organic matter digestibility = (0.8974*IVDMD) + 8.9273.

Table 3. Characteristics of hay fed to cow-calf pairs, dry cows, and yearling steers in Year 2.

	Hay offered	Hay refused	Actual Diet
Dry matter, %	79.7	85.8	--
Organic matter, %	89.9	89.8	89.9
Neutral detergent fiber, %	67.2	76.5	66.2
Crude protein, %	10.7	10.2	11.1
In vitro dry matter digestibility, %	51.8	46.5	52.9
In vivo organic matter digestibility[1], %	55.4	50.7	56.4
Undegradable intake protein, % of CP	45.5	53.2	44.1

[1]Calculated from equation (Geisert et al., 2007): In vivo organic matter digestibility = (0.8974*IVDMD) + 8.9273.

Table 4. Average ADG of yearling steers and calves consuming grass hay harvested from Sandhills meadow in Years 1 and 2.

	Year 1			Year 2		
	Start	End	ADG	Start	End	ADG
Yearling steers BW, kg	264.0	338.4	0.79	286.2	332.5	0.66
Calves BW, kg	68.5	166.9	1.05	77.6	150.0	1.03

Table 5. Milk production of cows nursing calves at start, midpoint(s), and end of Year 1 and Year 2.

	Start	Midpoint 1	Midpoint 2	End
Year 1 average, kg	4.7	2.4	1.4	2.5
Year 2 average, kg	3.3	3.9	n/a[1]	2.9

[1]Milk production was measured at one mid-point in Year 2.

Table 6. Body weight, MBW, DM, OM, IVDMD, and NDF daily intake of cow-calf pairs, dry cows and steers averaged for both years consuming grass hay harvested from Sandhills meadow.

	Cow-calf pair	Dry Cow	Steer	SE	*P*-value	
					trt	yr×trt
BW, kg	629^{x}	503^{y}	305^{z}	6	< 0.01	0.41
MBW[1], kg	117^{x}	87^{y}	60^{z}	0.7	< 0.01	0.31
DMI, kg	16.2^{x}	11.8^{y}	6.8^{z}	0.2	< 0.01	< 0.01
DMI, % of BW	2.58^{x}	2.37^{y}	2.24^{z}	0.04	< 0.01	< 0.01
DMI, % of MBW	13.80^{x}	13.62^{x}	11.39^{y}	0.20	< 0.01	< 0.01
OMI[2], kg	14.7^{x}	10.7^{y}	6.2^{z}	0.2	< 0.01	< 0.01
OMI, % of BW	2.34^{x}	2.15^{y}	2.03^{z}	0.03	< 0.01	< 0.01
OMI, % of MBW	12.49^{x}	12.34^{x}	10.33^{y}	0.17	< 0.01	< 0.01
IVDMDI[3], kg	8.6^{x}	6.3^{y}	3.7^{z}	0.2	< 0.01	< 0.01
IVDMDI, % of BW	1.38^{x}	1.26^{y}	1.20^{z}	0.02	<0.01	< 0.01
IVDMDI, % of MBW	7.35^{x}	7.26^{x}	6.10^{y}	0.12	< 0.01	< 0.01
NDFI[4], kg	10.5^{x}	7.7^{y}	4.4^{z}	0.1	< 0.01	< 0.01
NDFI, % of BW	1.68^{x}	1.54^{y}	1.45^{z}	0.02	<0.01	< 0.01
NDFI, % of MBW	8.97^{x}	8.84^{x}	7.38^{y}	0.13	< 0.01	< 0.01

[1]Metabolic body weight = $BW^{0.75}$.

[2]OM intake.

[3]IVDMD intake.

[4]NDF intake.

[xyz] Within a row, means without common superscript letters differ (*P* < 0.05).

Table 7. Average BW, MBW, DM, OM, IVDMD, and NDF daily intake of cow-calf pairs, dry cows and steers for Year 1 consuming grass hay harvested from Sandhills meadow.

	Cow-calf pair	Dry Cow	Steer	SE	*P* value
BW, kg	628^{x}	510^{y}	301^{z}	6	< 0.01
MBW[1], kg	117^{x}	88^{y}	59^{z}	0.8	< 0.01
DMI, kg	18.3^{x}	13.4^{y}	6.9^{z}	0.3	< 0.01
DMI, % of BW	2.91^{x}	2.62^{y}	2.27^{z}	0.05	< 0.01
DMI, % of MBW	15.52^{x}	15.18^{x}	11.53^{y}	0.30	< 0.01
OMI[2], kg	16.6^{x}	12.2^{y}	6.3^{z}	0.3	< 0.01
OMI, % of BW	2.64^{x}	2.39^{y}	2.07^{z}	0.05	< 0.01
OMI, % of MBW	14.12^{x}	13.83^{x}	10.50^{y}	0.26	< 0.01
IVDMDI[3], kg	9.8^{x}	7.2^{y}	3.7^{z}	0.2	< 0.01
IVDMDI, % of BW	1.56^{x}	1.41^{y}	1.22^{z}	0.04	< 0.01
IVDMDI, % of MBW	8.40^{x}	8.16^{x}	6.22^{y}	0.20	< 0.01
NDFI[4], kg	11.6^{x}	8.5^{y}	4.4^{z}	0.2	< 0.01
NDFI, % of BW	1.85^{x}	1.67^{y}	1.44^{z}	0.04	< 0.01
NDFI, % of MBW	9.87^{x}	9.67^{x}	7.30^{y}	0.19	< 0.01

[1]Metabolic body weight = $BW^{0.75}$.

[2]OM intake.

[3]IVDMD intake.

[4]NDF intake.

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

Table 8. Average BW, MBW, DM, OM, IVDMD, and NDF daily intake of cow-calf pairs, dry cows and steers for Year 2 consuming grass hay harvested from Sandhills meadow.

	Cow-calf pair	Dry Cow	Steer	SE	*P* value
BW, kg	630^{x}	497^{y}	309^{z}	10	< 0.01
MBW[1], kg	117^{x}	86^{y}	61^{z}	1.4	< 0.01
DMI, kg	14.1^{x}	10.3^{y}	6.8^{z}	0.2	< 0.01
DMI, % of BW	2.26^{x}	2.12^{y}	$2.20^{x,y}$	0.04	0.04
DMI, % of MBW	12.07^{x}	12.07^{x}	11.26^{y}	0.19	< 0.01
OMI[2], kg	12.7^{x}	9.2^{y}	6.2^{z}	0.2	< 0.01
OMI, % of BW	2.03^{x}	1.90^{y}	$1.99^{x,y}$	0.04	0.05
OMI, % of MBW	10.85^{x}	10.85^{x}	10.15^{y}	0.17	< 0.01
IVDMDI[3], kg	7.4^{x}	5.4^{y}	3.6^{z}	0.1	< 0.01
IVDMDI, % of BW	1.19^{x}	1.12^{y}	$1.17^{x,y}$	0.02	0.03
IVDMDI, % of MBW	6.35^{x}	6.35^{x}	5.98^{y}	0.09	0.01
NDFI[4], kg	9.4^{x}	6.8^{y}	4.5^{z}	0.1	< 0.01
NDFI, % of BW	1.51^{x}	1.40^{y}	$1.46^{x,y}$	0.03	0.05
NDFI, % of MBW	8.06^{x}	8.00^{x}	7.47^{y}	0.14	0.01

[1]Metabolic body weight = $BW^{0.75}$.

[2]OM intake.

[3]IVDMD intake.

[4]NDF intake.

^{xyz} Within a row, means without common superscript letters differ ($P < 0.05$).

Table 9. Comparison of DMI from current study with suggested intakes from selected extension and other peer-reviewed publications.

Source	Class of animal	Suggested/Actual Daily DMI, kg	Daily DMI, %BW
Present study[1]	Lactating cow with calf < 3 months of age (629 kg)	16.2	2.6
Present study	Dry cow (503 kg)	11.8	2.4
Present study	Yearling steer (305 kg)	6.8	2.2
Scarnecchia and Kothmann, 1982	Animal not defined	11.8	2.6
Gerrish and Roberts, 1999	499 kg cow without calf	15.1	3.0
Waller et al., 1986	454 kg cow, above average milking ability, with a calf < 3-4 mo postpartum	10.3	2.3
SRM, 1989; ISU, 1998; USDA NRCS, 2003	Mature cow of about 454 kg, either dry or with calf up to 6 mo of age	11.8	2.6
USDA NRCS, 2003	Dry cow	10.9	
USDA NRCS, 2003	Cattle, 1 yr old	7.1	

[1] Intake values are taken from Table 6, which measures both years of the present study.

Table 10. Comparison of intakes (DM and/or OM basis) from selected research.

Source	Class of animal	Suggested/Actual Daily DMI, kg	Daily DMI,%BW	Daily OMI,% BW
Present study[1]	Lactating cow with calf < 3 months of age (629 kg)	16.2	2.6	2.3
Present study	Dry cow (503 kg)	11.8	2.4	2.2
Present study	Yearling steer (305 kg)	6.8	2.2	2.0
Hollingsworth-Jenkins et al., 1995	103-231 kg nursing calf, approx. age 3-6 mo	--	--	1.1-1.5
Hollingsworth-Jenkins et al., 1995	Mid lactation cow, 454-540 kg	--	--	2.4-2.6
Patterson et al., 2003	Lactating 2 yr old heifer	--	--	2.4
NRC, 1996	Lactating cow with calf < 3 months of age (629 kg)	13.1		
NRC, 1996	Dry cow (503 kg)	9.5		
NRC, 1996	Yearling steer (305 kg)	7.7/8.0[2]		

[1] Intake values are taken from Table 6, which measures both years of the present study.

[2]Intake was 7.8 kg when the NE_m adjuster was not used, 8.1 kg when the NE_m adjusted at 120% (Block et al., 2006).

Table 11. Average age, BW at weaning, BCS at weaning, BW at start of trial, and BW at end of trial for lactating and non-lactating cows.

	Age, yr	BW at Weaning, kg	BCS at Weaning	Start Trial BW, kg	End Trial BW, kg
Lactating cows	6	516	5.3	514	531
Non-lactating cows	6	509	5.3	504	559

Table 12. Comparison of DMI (actual and as % BW) across **both years** of cow-calf pair, dry cow, yearling steer, cow-calf pair with calf BW removed, and lactating cow only.

	Cow-calf pair	Dry Cow	Steer	Cow-calf pair minus calf BW[1]	Lactating cow minus calf BW and intake[2]
BW, kg	629	503	305	513	513
DMI	16.2	11.8	6.8	16.2	14.8
DMI, %BW	2.58	2.37	2.24	3.16	2.88

[1]Average calf BW (116 kg) subtracted from average cow-calf pair BW

[2]Average calf BW (116 kg) subtracted from average cow-calf pair BW and calf DMI (1.1% BW OM, Hollingsworth-Jenkins et al., 1995, converted to DMI using 90.6% OM, current study) subtracted from cow-calf pair daily DMI.

Table 13. Comparison of DMI (actual and as % BW) for **Year 1** of cow-calf pair, dry cow, yearling steer, cow-calf pair with calf BW removed, and lactating cow only.

	Cow-calf pair	Dry Cow	Steer	Cow-calf pair minus calf BW[1]	Lactating cow minus calf BW and intake[2]
BW, kg	628	509	301	510	510
DMI	18.3	13.3	6.8	18.3	16.9
DMI, %BW	2.91	2.62	2.27	3.59	3.31

[1]Average calf BW (118 kg) subtracted from average cow-calf pair BW

[2]Average calf BW (118 kg) subtracted from average cow-calf pair BW and calf DMI (1.1% BW OM, Hollingsworth-Jenkins et al., 1995, converted to DMI using 90.6% OM, current study) subtracted from cow-calf pair daily DMI.

Table 14. Comparison of DMI (actual and as % BW) for **Year 2** of cow-calf pair, dry cow, yearling steer, cow-calf pair with calf BW removed, and lactating cow only.

	Cow-calf pair	Dry Cow	Steer	Cow-calf pair minus calf BW[1]	Lactating cow minus calf BW and intake[2]
BW, kg	630	497	309	516	516
DMI	14.2	10.3	6.8	14.2	12.8
DMI, %BW	2.26	2.12	2.20	2.75	2.48

[1]Average calf BW (114 kg) subtracted from average cow-calf pair BW

[2]Average calf BW (114 kg) subtracted from average cow-calf pair BW and calf DMI (1.1% BW OM, Hollingsworth-Jenkins et al., 1995, converted to DMI using 90.6% OM, current study) subtracted from cow-calf pair daily DMI.

Figure 1. Dry matter intake as % BW for cow-calf pairs, dry cows, and yearling steers consuming grass hay harvested from Sandhills meadow compared across both years, Year 1, and Year 2.