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# SUPPLEMENTING DISTILLERS GRAINS IN EXTENSIVE BEEF CATTLE SYSTEMS

By

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#### A DISSERTATION

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree Doctor of Philosophy

Major: Animal Science

Under the Supervision of Professors Terry J. Klopfenstein and L. Aaron Stalker

Lincoln, Nebraska

December, 2011

# SUPPLEMENTING DISTILLERS GRAINS IN EXTENSIVE BEEF CATTLE SYSTEMS

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University of Nebraska, 2011

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A 3-yr study evaluated effects of supplementing modified wet distillers grains with solubles during summer grazing and subsequent feedlot sorting on long yearling steers. During summer grazing, supplemented steers had greater ADG and were more profitable than non-supplemented steers. At feedlot entry, supplemented steers were 48 kg heavier than non-supplemented steers. Feed efficiency and DMI were not different between supplementation treatments during finishing. Supplemented steers were fed 24 fewer days to reach a similar 12<sup>th</sup> rib fat thickness, had greater LM area, and lower marbling compared to non-supplemented steers. Overall profitability favored supplementing steers because less expensive summer gains also reduced feedlot inputs. Sorting on feedlot entry BW increased HCW, marbling, and YG. However, percentage overweight carcasses and profitability were similar between the sort treatments.

An ongoing 3-yr trial was conducted to elucidate effects of weaning date and prepartum nutrition on cow-calf productivity in a spring calving system. The first 2-yr of data found dams weaned in October weaned cows grazing winter range had greater BCS and BW compared to December weaned cows pre-calving. Dams on a higher nutritional plane from winter grazing treatment had greater BCS and BW prior to parturition and breeding. However, subsequent pregnancy rates for cows were similar among weaning and winter grazing treatments. Calves born to dams on a higher nutritional plane had greater BW in October and December, and adjusted weaning BW. There were no differences in percentage cycling prior to breeding or pregnancy rate of heifer progeny. Steer progeny had greater HCW and 12<sup>th</sup> rib fat thickness at harvest. Net change in return was greatest when October weaned dams were wintered on corn residue and December weaned dams were on winter range with 0.91 kg supplement if calves were sold at weaning. When ownership was retained, steer progeny born to dams on corn residue during winter grazing resulted in the greatest net change in return.

# **DEDICATION**

For Dad.

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#### **CHAPTER I**

#### A Review of the Literature

#### Introduction

Feed is the largest variable cost in beef production, totaling approximately twothirds of the cost in U.S. beef cattle production (Anderson et al., 2005). In life-cycle beef
production, feed energy requirements simply for maintenance of animals (i.e., not
including the feed costs of productive functions like growth or lactation above the
requirements for maintenance) account for ~70% of feed inputs (Williams and Jenkins,
2006). Thus, inexpensive management strategies that effectively reduce input costs are
extremely valuable, especially in growing production systems. Multiple forage and
supplemental energy/protein sources are available for beef production in Nebraska,
offering flexibility to producers. Over 75% of the beef calves in the U.S. will be
backgrounded on forage before entering finishing in the feedlot (Peel, 2000),
emphasizing the importance of developing a variety of backgrounding programs to meet
the producer demand.

In animal biological systems, differences in gain efficiency, muscle and adipose deposition, and overall mass become more apparent as animals grow. Different combinations of feed resources, genetic and phenotypic variation, and a steady demand for beef, lead to different endpoints for cattle, which may result in an inconsistent end product available to the consumer. The most recent National Beef Quality Audit indicates a lack of uniformity in carcass cuts and insufficient marbling as the highest

concerns of beef merchandisers (Shook et al., 2008). Clearly, techniques to enhance beef consistency that align consumer demand with production goals are needed.

The United States has a diverse population of beef cattle available for use.

Optimizing production can only be achieved if the desired breed or breed combination of animal complements the environment and management system chosen by the producer (Adams et al., 1996). Nutrient requirements also increase during times of physiological change, such as gestation and lactation, and are at their highest for cows approximately 60 d post-partum. Second to this is the last third of the gestation period, when the greatest amount of fetal growth occurs (Eley et al., 1978). However, forage quality declines as the growing season progresses. Several resources are available to better align cow requirements with forage nutrients, such as weaning date and nutritional supplements, keeping in mind that in-utero nutritional stresses play a pivotal role in subsequent cow-calf performance.

The goals of this literature review are to 1) introduce the long yearling production system, 2) review supplementation strategies for long yearlings, 3) discuss feedlot sorting techniques used to increase beef uniformity, 4) introduce fetal programming, 5) evaluate time of weaning as a method to influence cow-calf production, and 6) discuss the importance of third trimester nutritional plane and effects on cow-calf production.

#### **Yearling Production Systems**

#### Matching cattle to system

Assessment of cattle type is the subjective visual appraisal of an individual or groups of animals based on various phenotypes (hide color, frame size, thriftiness).

Camfield et al. (1999) defined carcass differences of four biologically different types of cattle fed on pasture or in a feedlot. They were: 1) large framed and late maturing; 2) medium framed and medium maturing; 3) medium framed and early maturing; and 4) small framed and early maturing. Steers were fed for equal days in the feedlot, and at the time of harvest the later maturing animals had greater BW, less FT, KPH, marbling, and were less developed physiologically. Results also confirmed that larger framed steers had the heaviest average BW. The intent of the experiment was not to directly compare steers finished on grass to those finished in a feedlot. But, the data illustrated inherent differences in the two production systems, in that adequate nutrients must be provided to animals to promote growth and development. The authors concluded this experiment could serve as an example to producers looking to better match cattle growth type with feeding practices and resources.

Interestingly, Tatum et al. (1986b) observed frame size was a significant source of variation of absolute growth rate during the finishing phase of production. Dolezal et al. (1993) provided excellent insight into the importance of correctly placing cattle into appropriate production systems. In this study, steers identified as calves were fed a finishing diet for 251 d; yearlings were backgrounded on corn silage for 112 d, and then fed a finishing diet for 166 d; and long yearlings were backgrounded on corn silage for 280 d before placement on a finishing diet for an average of 98 d. Results showed within age class, differences in harvest traits corresponded with respective stages of development. Long yearling steers were slower at depositing fat, had heavier final BW, and deposited more total fat than the other 2 groups when compared at a similar 12<sup>th</sup> rib

fat thickness. Furthermore, delaying finishing of smaller framed animals may be an effective tool to maximize growth potential, which will increase HCW and better meet consumer based market goals.

Adams et al. (2010) tested the hypothesis that genetically similar cattle could be matched with the appropriate production system based off feedlot entry BW. Each yr of a 2 yr experiment, half the steers were not sorted and the remaining half were sorted by entry BW. At random, 33% of the non-sorted steers were placed into a calf-fed system (182 d finishing), 33% were placed into a summer yearling system (197 d backgrounding, 139 d finishing), and 33% were placed into a fall yearling system (306 d backgrounding, 124 d finishing). The sorted cattle were separated into 3 groups based on feedlot entry BW (33% heaviest were calf-feds, 33% middle weights were summer yearlings, 33% lightest were fall yearlings). Sorting cattle into respective production systems based on BW successfully decreased initial BW and HCW and percentage overweight carcasses, without negatively impacting feedlot performance.

#### Phases of production

Yearling production systems capitalize on use of the animal to harvest forage; as opposed to more intensive systems, that require harvested forages and longer grain feeding. Typically, yearling cattle are lighter BW and smaller framed than contemporaries; whereas calf-fed animals are heavier and larger framed at weaning. Yearling production systems are further segregated into: short yearlings, which are weaned in the fall, backgrounded during the winter, then enter the feedlot in the spring; or long yearlings, which are weaned in the fall and backgrounded for approximately 1 yr,

at which time they enter the feedlot. Regardless of calf-fed or yearling growing systems, the nutrient requirements of growing animals are characterized by the growth potential of the animal and the nutrients supplied through feed. In general, protein and energy requirements increase with increased BW gain (NRC, 1996).

Winter. In Nebraska, wintering growing calves on corn residues is an excellent way to economically harvest the forage and reduce feed costs because crop residue is often valued less than dormant range. When available, corn residue is often preferred over dormant winter range because the nutritive value is greater. Greater CP and digestibility of residual corn, husks, leaves, and cobs contribute to greater nutritive value of corn residue compared to dormant forage. This feed quality advantage increases BW and ADG of cattle on corn residue over cattle grazing native range (Clanton et al., 1989). However the first limiting nutrient of corn residue is protein and growing calves require about 0.16kg DM/d supplemental RUP to meet nutrient requirements (Fernandez et al., 1988). Jordon (2000) found the optimum feeding level of wet corn gluten feed to calves grazing corn residue is 2.72 kg DM/animal daily, leading to about 0.84 kg ADG.

Summer. A combination of cool and warm season pastures are often utilized after grazing corn residue in high forage production systems. In general, CP of cool season grasses in Nebraska peak in late April to early May, steadily decline in CP until early August, when the CP will rebound slightly during a short re-growth period, lasting until mid-October. Warm season grasses, on the other hand, will reach peak CP values in mid-June to early July, and then decline in CP more gradually until December without a re-growth period. Research supports these quality values and suggests quality of diets

selected by cattle is similar across the state of Nebraska (Geisert et al., 2008). Because the protein in forages is highly degradable (Buckner et al., 2011) supplemental RUP may be necessary to meet a deficiency in metabolizable protein (Creighton et al., 2003). Supplements high in RUP are beneficial because cattle are able to use this type of protein more efficiently and excess protein can be recycled in the body to be later used as RDP.

Finishing. In a 3-yr study, Lewis et al. (1990) compared a more traditional intensive beef production system to an alternative extensive program. After weaning, calves were assigned to 1 of 2 treatments: 1) placed directly in the feedlot (236 d) or 2) backgrounded on corn residue (195 d), grazed pastures (115 d), and entered the feedlot to be finished (122 d). Cattle in the extensive system entered the feedlot at heavier weights, had greater DMI, and ADG during the finishing phase than intensive contemporaries. Although cattle in the intensive system were more efficient in the feedlot, the extensive production system produced cattle that were heavier at harvest; and thus, more pounds of beef were produced. This is supported by research that shows extending the growing phase of smaller cattle with forage based systems may increase HCW and produce more retail product at a constant fat thickness (Turgeon, 1984).

Economics. If smaller cattle are placed in an intensive production system where they are weaned and fed a high concentrate diet until harvest, they may produce lighter HCW (Turgeon, 1984). Cattle growth potential and BW must be managed carefully because weight sold is one of the primary drivers of profitability of beef production (Fuez, 2002; Shain et al., 2005; Tatum et al., 2006). Yearling cattle have greater final BW compared to calf-feds and require less time in the feedlot to reach a similar endpoint;

and thus may be more profitable (Griffin et al., 2007; Folmer et al., 2008; Adams et al., 2010b). However, if cattle are fed too long they run the risk of producing overweight carcasses. This is especially true for larger framed cattle (Vieselmeyer, 1993). Clearly, placing cattle into the correct management system is critical for overall profitability if ownership is retained through harvest. Marketing time may also benefit the yearling production system, because more than 50% of profit variation is due to fed and feeder cattle prices (Koknaroglu et al., 2005).

#### Supplementation with distillers grains

Within a given production system, cattle may be supplemented for several reasons: correct a nutrient deficiency, conserve forage, improve animal performance, or improve profitability. Cereal grain supplementation in forage based diets depresses fiber digestion; however, this may be overcome through high fiber energy supplement strategies. Summarized animal growth data indicate the energy in corn fiber from corn bran or corn gluten feed is similar or greater than the energy found in corn (Oliveros et al., 1989). Digestibility results show corn fiber in by-products is less likely to cause negative associative effects compared to supplemental corn in forage based diets (Loy et al., 2007; Leupp et al., 2009).

Distillers grains (**DGS**) appear to fit very well into high forage systems because they provide P, RUP, and additional energy. Distillers grains are approximately 30% CP, 51% (Buckner et al., 2011) to 60% (Ham et al., 1994) of the CP is RUP, and 0.7% to 1.0% P (Spiehs et al., 2002). The fiber in DGS and additional fat are also excellent sources of energy to grazing animals. MacDonald et al. (2007) evaluated the relative

contributions of UIP in DDG. Heifers provided with UIP concentrations equal to that of DGS resulted in 39% as great ADG compared to heifers fed DGS, indicating over one-third the response to DGS may be due to meeting a metabolizable protein deficiency during summer grazing. Phosphorus requirements of cattle have likely been overestimated, especially in finishing diets (Erickson et al., 2002; Geisert et al., 2010).

Animal response. Due to these nutrient advantages, supplementing wet DGS (WDGS) or dry DGS (DDGS) to cattle on forage based diets or grazing pasture has been shown to improve animal performance. In fact, several experiments have shown a linear increase in retained energy (ADG and BW) with increasing levels of DDGS supplemented (Morris et al., 2005, 2006; MacDonald et al., 2007; Jenkins et al., 2009; Griffin et al., 2011). Watson (2010) observed a 40 kg BW advantage to supplementation of DDGS at 0.6% BW for 158 d over non-supplemented yearling steers. On the other hand, Morris et al. (2005, 2006) observed an 11 to 16 kg BW advantage to supplementation of DDGS at 0.6% BW for 88 or 84 d compared to non-supplemented animals. In addition, some research has found a quadratic ADG response to increasing levels of DGS supplementation (Corrigan et al., 2009; Griffin et al., 2011).

Possible explanations of variation in animal response could be nutritive value of basal diet, level of supplementation, animal management, and interaction with level of dietary fat. Forage quality and quantity, whether it is standing or previously harvested, will have a significant effect on animal response to supplementation. Forage energy and CP are highest during periods of active growth and declines as the season progresses.

Assuming quantity is not limiting, higher quality forage will better meet requirements of

growing cattle. Morris et al. (2005) individually supplemented heifers increasing levels of DDGS fed high or low quality forages which were designed to simulate winter range or hay feeding and grazed summer range, respectively. Regardless of forage quality, ADG increased with increasing levels of DDGS supplementation, but the increase in the rate of gain was greater for heifers fed low quality forage than high quality forage.

Animal management will impact results of experiments. In the case of Griffin et al. (2011), pasture supplementation and confinement supplementation experiments were compared. Results of the meta-analysis found response to DGS supplement was different between the 2 management systems. Authors concluded performance response is in fact quadratic, but increased variation due to the inherent nature of pasture experiments caused inconsistency in statistical differences. Research has shown fat may compromise fiber digestibility in the rumen (Pavan et al., 2007; Hess et al., 2008). Corrigan et al. (2009) fed increasing levels DG with varying levels of condensed distillers solubles (CDS), whereas all other experiments fed levels of DG + CDS (DGS) together, increasing at the same relative rate. Condensed distillers solubles has a higher proportion of ether extract than DG alone. But researchers have hypothesized that fiber digestion is not inhibited if fat does not surpass 6% diet DM (Doreau and Chilliard, 1997). It is difficult to identify with certainty the sources of variation in the magnitude of response to DGS supplementation, but collectively these data show increased ADG and BW of cattle supplemented with DGS over non-supplemented cattle.

*Forage replacement.* Decreased forage intake with DGS supplementation is well documented. This can be explained by decreased average rumen pH and rate and extent

of NDF disappearance of supplemented animals compared to non-supplemented animals (Loy et al., 2007). In general, forage intake decreases with increasing levels of DGS supplement (Morris et al., 2005, 2006; MacDonald et al., 2007; Corrigan et al., 2009; Leupp et al., 2009). As discussed briefly earlier, DGS are a unique feedstuff because when fed in forage-based systems, forage intake is depressed, but animal performance is improved.

Conserving forage resources is of primary importance due to the difficulty and expense in acquiring them. Therefore, supplementation has been viewed as a tool to extend grazing season and/or increase stocking rate. Forage intake estimates from DGS supplemented cattle suggest opportunities for 10 (MacDonald et al., 2007) to 31% (Watson, 2010) increase in stocking rates. In fact, when growing calves were fed harvested forages and supplemented with DGS, Klopfenstein et al. (2007) predicted forage replacement up to 50%. Gustad et al. (2008) tested the upper limits of forage replacement by doubling the stocking rate (2.47 AUM/ha) of experimental paddocks under normal grazing pressure (1.23 AUM/ha). Interestingly, researchers did not find significant reduction in forage removal from DDGS supplementation. It is possible level of forage replacement was overestimated when treatments were considered; thus, the design and sampling procedures were not sensitive enough to measure differences. Authors also cautioned readers DDGS supplementation of yearling cattle may replace forage, but not such that a twofold increase in stocking rate is advised.

Subsequent feedlot performance. Little supplementation work with DGS has focused on subsequent feedlot performance. Added BW gain achieved through DGS

supplementation will cause heavier animals to be placed into the feedlot. Because heavier cattle require fewer days fed to produce similar carcasses as lighter cattle, these previously supplemented animals must be managed differently than non-supplemented counterparts. Yearling cattle given ad libitum access to DDGS during summer grazing (53 d) entered the feedlot 27 kg heavier than non-supplemented contemporaries (Funston et al., 2007). To reach a similar final BW and 12<sup>th</sup> rib fat thickness, supplemented steers were fed 14 fewer days in the feedlot than steers not given access to DDGS, but no differences were observed in feedlot ADG, DMI or G:F. Similarly, Morris et al. (2006) observed that supplemented steers entered and exited the feedlot 17 kg heavier than non-supplemented steers. Greenquist et al. (2009) observed similar ADG and greater final BW of supplemented than non-supplemented steers. However, the difference (37 kg) in feedlot entry BW between supplemented and non-supplemented cattle was similar to the difference (41 kg) between treatments at the time of harvest.

Compensatory growth may or may not be observed in cattle depending on the severity of the nutrient restriction. Data from Morris et al. (2006) and Funston et al. (2007) indicated supplementing with DDGS will not result in compensatory gain of the non-supplemented cattle because feedlot ADG was not different. Greenquist et al. (2009) also suggested non-supplemented cattle do not exhibit subsequent compensatory gain in the feedlot. However, other research observed non-supplemented calves had a 0.12 kg/d increase in feedlot ADG compared to DDGS supplemented calves (Lomas and Moyer, 2008).

Carcass characteristics. Limited data show no differences in carcass characteristics between supplemented and non-supplemented animals (Morris et al., 2006; Funston et al., 2007). However, there may be a tendency for cattle supplemented with DGS to produce fatter carcasses. Greenquist et al. (2009) and Watson et al. (2010) observed greater marbling scores for supplemented compared to non-supplemented steers. Interestingly, cattle on finishing diets containing DGS may have altered lean and adipose tissue deposition compared to cattle without DGS fed equal days (Koger et al., 2010; Schoonmaker et al., 2010). Funston et al. (2007) found a tendency for DGS supplemented cattle to have a higher percentage grading choice when compared to non-supplemented cattle. Past research with suckling calves has also shown that creep feeding will increase quality grade (Faulkner et al., 1994). These data are inconsistent and it is difficult to conclude supplementing during summer grazing is the cause of change in carcass composition.

Economics. Distillers grains have proven to be an attractive option for supplementation programs because they are valued at approximately 70 to 90% the price of corn. Decreased cattle on feed during summer months typically lower demand for DGS. Although growing cattle will likely respond to DGS supplementation, the performance and price advantages must outweigh alternative approaches. Several different factors that influence the overall economic outlook of a supplementation strategy include, but are not limited to: price of supplement, level of supplement, labor, delivery cost, animal performance, forage replacement, and subsequent feedlot cost of gain (if ownership retained).

The value of supplementing DGS is best determined by the combination of improved animal performance and reduced feed intake. The overall value of supplementing DDGS may be higher in low quality versus high quality forage based systems (Morris et al., 2005). Regardless of forage quality, supplementing DDGS is more economically advantageous than not supplementing (Morris et al., 2005). In addition, breakeven costs may decrease if ownership of cattle is retained through harvest (Morris et al., 2006); however, total value of DDGS supplement may be over \$8.00/metric ton higher if cattle are sold after summer grazing (Funston et al., 2007). Level of supplementation will also influence overall profitability of DDGS supplementation. Jenkins et al. (2009) concluded risk was lowest when 0.5% BW of DDGS was supplemented because it was the only strategy that did not result in negative net returns, within their price and marketing assumptions. Thus, marketing decisions must be managed carefully and will change within each production scenario.

#### Subsequent feedlot sorting

Cattle are sorted in the feedlot to produce a more uniform lot at the time of harvest. Sorting can take place any time from feedlot entry until just prior to shipment for harvest. Several different types of measurements have been made and account for different portions of cattle growth rate and carcass variability. In general, the closer to harvest predictive measurements are taken, the better the measurements are at predicting carcass composition.

**Body measurements.** Breed, frame size, hip height, muscle score, age, BW and fatness are all indicators of animal potential, which have been used to predict carcass and

performance traits. Frame size is a significant source of variation of absolute growth rate during the finishing phase of production (Tatum et al., 1986b). In general, using measures of skeletal size, age, and BW, as well as an estimate of body fatness collectively, will increase accuracy of carcass weight and compositional predictions (Hammack and Shrode, 1986). But, the lack of objectivity and constancy of measurement locations in these assessments often negates their usefulness as a measurement tool applied across production scenarios. Contradictory data of various body measures offer very little confidence in their degree of usefulness as a tool to predict cattle performance, carcass characteristics, and ultimately, carcass value (Hammack and Schrode, 1986; Trenkle et al., 1986a; Trenkle et al., 1986b; Trenkle et al., 1986c; Comerford et al., 1988).

Subjective measurements of frame, fat and muscle, as well as initial BW and breed classification explain up to 50 and 32% of the variation in HCW and days on feed, respectively (Butts et al., 1980b). More objective measurements using ultrasonic technologies were also evaluated, and improved explanation of variation of HCW and days on feed by 8% and 12.5%, respectively (Butts et al., 1980a). Thus, it appears ultrasound may be a useful tool to increase reliability of predicting time required to adequately finish beef cattle and the weight at which they will be harvested.

Still, one of the easiest and least expensive methods to predict animal performance is by measuring BW. And this is important because the most valuable indicator of carcass weight is live animal BW (MacDonald et al., 2006). Not only does BW account for variability in growth and performance (Williams et al., 1992; Keele et

al., 1992), but it also explains animal-to-animal variation in percent retail yield (Greiner eta l., 1997). In fact, BW and age may explain over 60% of the variation in BW gain (Hammack and Schrode, 1986). That being said, increasing days fed during the finishing phase of production and marketing cattle on a grid will result in increased profit due to additional weight sold (Fuez, 2002).

Strategies. Feedlot sorting strategies are designed with a specific management goal in mind, which is often economically driven. When cattle are grid priced, potential discounts include, but are not limited to overweight and overfat carcasses. Due to the advantages of optimizing days fed and weight sold, sorting may be used as a tool to increase total carcass weight.

Prevention of outlier carcasses by sorting cattle based on ultrasonic measurements may result in overestimation of carcass fatness. Yearlings sorted on ultrasound measurements of carcass fatness were harvested too early compared to visually sorted contemporaries, in an experiment conducted by Peterson et al. (2003). Using ultrasound technology to predict days on feed resulted in decreased YG and QG. Cattle that will produce overweight carcasses can be identified by BW at the time of re-implant (approximately 90 d pre-harvest), but YG 4 carcasses are not consistently identified by ultrasound or manual palpation (Cooper et al, 1999). In this study, re-implant BW explained 21 to 74% of the variability in HCW; whereas, ultrasound re-implant fat thickness and palpation re-implant fat thickness only account for 15 to 25% and 5 to 12% of carcass fat thickness variation. The authors recommend the use of BW alone as a tool

for sorting to prevent overweight carcasses, and cautioned producers against the prediction of carcass fatness due to high variability in estimates.

MacDonald et al. (2006) was unable to increase HCW or reduce overweight or overfat carcasses when several different sorting strategies were employed. Yearling steers sorted on feedlot entry BW were fed an average of 7 d longer and had 13 kg greater final BW than non-sorted steers. Additionally, sorting heavier cattle off mid-summer grazing (July) and sorting cattle into 2 groups (light, heavy) based on feedlot entry BW reduced HCW variation. This is important to consider, because as BW variation increases net returns decrease (Smith et al., 1989). But, sorting cattle by BW and 12<sup>th</sup> rib fat thickness at the end of the feeding period was not successful in reducing HCW variation. Less response to sorting than anticipated may have been due to inadequate time on feed during the finishing phase. Authors suggest sorting cattle into 3 BW groups as a more appropriate strategy because it may more closely reflect the BW distribution of cattle.

Folmer et al. (2008) evaluated effects of sorting cattle into 3 groups (25% light, 50% medium, 25% heavy) based on feedlot entry BW, compared to a non-sorted control group. As a result, sorted cattle were fed 6 d longer, had 9 kg greater final BW and 0.15 kg/d greater DMI than cattle not sorted. Sorting reduced overweight carcasses by over 8.0%. Moreover, variation analyses showed a 37.5% reduction in HCW variability when the 3-way sorting strategy was utilized. Griffin et al. (2009) used a similar strategy and found no benefit to sorting yearling steers on feedlot entry BW because HCW and overweight carcasses were not reduced, while overfat carcasses increased.

*Economics*. Reduced pen space efficiency when fatter cattle are sorted off early and lost yardage are of economic concern to feedlot operators; as well as the quality of lighter cattle still remaining in the pen. However, topping off pens may increase overall profitability because leaner, more efficient cattle are left in the pen after the harvest ready cattle are sorted off, and will benefit from additional days on feed (Cooper et al., 2000). MacDonald et al. (2006) was unable to improve profitability when cattle were sorted on BW mid-summer, at feedlot entry, or in combination with 12<sup>th</sup> rib fat thickness measurements prior to harvest. However, marketing heavier yearling cattle mid-summer increased premiums, but this benefit was offset by decreased HCW. These data emphasize the need to develop sorting strategies effective at increasing profitability.

In a follow up experiment by Folmer et al. (2008), sorted steers had greater total production costs, but breakeven and feedlot cost of gain were similar with non-sorted yearlings. Interestingly, live value and grid value were \$14.74 and \$28.62/animal greater for sorted steers. Profitability was not different between sorted and non-sorted steers because the increased costs of production with sorting were greater than the increased value. A simulation analysis predicted discounts for overweight and yield grade 4 carcasses can reach as high as 15% of a feedlot pen and still not exceed the benefit of selling more weight and higher quality carcasses (Fuez et al., 2002). Griffin et al. (2009) does not support this. Long yearling steers sorted on feedlot entry BW had increased yield grade 4 carcasses, with no difference in quality grade and only a 3 kg benefit in HCW to offset the discounts. However, Fuez et al. (2002) suggested increasing time on

feed by 14 d, and Griffin et al. (2009) fed sorted cattle only 3 d longer than non-sorted cattle.

Although the benefits of sorting cattle have not shown consistent increases in profitability, variation in BW groups marketed and time on feed may be the cause. It is also possible due to the inherent nature in BW and carcass composition variability, these studies did not have enough power to statistically differentiate treatment effects (Kononoff and Hanford, 2006). Biologically and economically, cattle should benefit from additional time on feed until the costs of production outweigh the additional value of added weight sold. Clearly, low cost BW management and appropriate marketing strategies are necessary to achieve the desired economic benefit.

#### **Cow and Calf Production Systems**

#### Matching nutrients and requirements

Protein and energy requirements of cattle generally increase with increased BW gain (NRC, 1996). Nutrient requirements also increase during times of physiological change, such as gestation and lactation, and are at their highest for cows approximately 60 d post-partum. Second to this is the last third of the gestation period, when the greatest amount of fetal growth occurs (Eley et al., 1978). Body energy reserves of cows can be effectively measured using a 1 to 9, or BCS (Herd and Sprott, 1986). It has been recommended dams be in moderate condition (BCS of 5) at parturition to ensure optimal reproduction and pre-weaning calf performance (Richards et al., 1986; Houghton et al., 1990; Morrison et al., 1999).

The synchrony of cow requirements with forage nutrients has been recommended as a management technique to efficiently develop and maintain forage based production systems (Adams et al., 1996). If done correctly, cattle will receive a majority of nutrients required from grazed forages. However, the cyclic nature of forages (*see Phases of growth/production: Summer*) and the dynamics of cattle requirements make the optimum point of this management tool a moving target. In a spring calving system, peak lactation and breeding events occur when forage quality and production are increasing; whereas, weaning occurs when forage nutrients are decreasing. Although several resources are available to better align requirements with resources available, such as weaning date and nutritional supplementation, in-utero nutritional stresses may play a more pivotal role in subsequent cow-calf performance.

#### Fetal programming

Recently, effects of fetal programming have been researched in multiple species, but the concept has long been established as the link between pre-natal nutrition and subsequent mature health (Barker et al., 1989). The general theory of fetal programming is that maternal stimulus has the potential to impact subsequent developmental processes of progeny affecting physiology and growth. Under-nutrition causes suboptimal conditions in the maternal uterine environment which translates into depressed growth efficiency and negative impacts on body composition (Wu et al., 2006; Larson et al., 2009). Therefore, this topic has become increasingly important to animal scientists in efforts to produce more efficient livestock with lower costs, especially considering rising prices and current market volatility. Unfortunately, the exact mechanisms causing these

deleterious responses are complex and not well understood (Funston et al., 2010). Focusing on specific management practices may be the most practical approach for beef cattle research to evaluate these interactions from a systems context.

#### Time of weaning

Adjustment of weaning date is a viable method to extend grazing season; thus, decreasing total purchased forage needs. Additionally, early weaning cows will lower nutrient requirements, increase BCS, and increase BW prior to calving, which is the critical point for reproduction efficiency. This critical point is especially important in a spring calving system because dormant forages often do not supply adequate nourishment to gestating cows.

Cow - calf performance. In a spring calving system, early weaning may be used to build body reserves in preparation for high nutrient demands of winter and the last trimester of gestation. Conversely, delaying weaning may cause cow BW and BCS to decrease. In an April calving system, Short et al. (1996) weaned cows 150 or 210 d post-partum and observed that at the time of the late wean, nursing cows weighed 32 kg less and had over 1.0 unit less BCS compared to dams weaned in September. In the same experiment, December weaned cows also had less BW and BCS pre-calving. Myers et al. (1999) took a similar approach and observed a linear increase in cow BW and BCS when calf weaning age decreased from 90 to 215 d. Extending age of calf at weaning to 270 d has been shown to have a similar impact on cow BW and BCS (Story et al., 2000). Weaning dams eliminates nutrients required for lactation, thus allowing nutrients consumed to be partitioned to BW and BCS gain.

However, if BCS is too low cows may not breed back, or re-breed as quickly. Interestingly, Myers et al. (1999) found a 12% improvement in subsequent pregnancy rate when dams were weaned at 90 d post-partum. Weaning 3 yr old heifers' 82 d post-partum increased subsequent pregnancy rates by 50%, and lowered calving interval (Arthington et al., 2003). However, other research indicates time of weaning may have minimal impact on subsequent pregnancy rates or calving interval (Basarab et al., 1986; Short et al., 1996; Story et al., 2000; Stalker et al., 2007). Story et al. (2000) found replacement rate of early weaned dams was greater than normal and late weaned females (11% vs 7% and 6%). In this study, cow replacement rate was based on lack of pregnancy, aborted calves, and calves born dead. Because pregnancy rates were similar among weaning dates, one could question if early weaning affects calf mortality or health. Stalker et al. (2007) observed no difference in percent calves weaned or calf health when March calving cows were weaned in August or November.

Differences in reproductive response from weaning date manipulation may be due to nutritional status of the cows, cow age, post-partum cow management, time of weaning, and power of data reported. Average BCS of cows in Short et al. (1996) was 5.6, 5.4 in Story et al. (2000), vs. 4.0 in Myers et al. (1999) and 4.9 in Arthington et al. (2003). Effects of early weaning may be more easily measured in young cows or thin cows because nutrient requirements are greater and more easily influenced during times of physiological change. Increased nutritional status of cows' post-partum has been shown to increase pregnancy rates and shorten post-partum interval (Lardy et al., 2004; Wettemann et al., 2003); thus, differences in post-partum management may play a pivotal

role in reproductive response. Also, only 1 and 2 yr of data were reported in Myers et al. (1999) and Arthington et al. (2003), compared to the other experiments which summarized cow response from at least 3-yr within each study or had a larger cow population represented during the test periods.

Long term effects of weaning time on cow and calf performance must also be evaluated to determine the sustainability of management decisions. A 5-yr experiment using 180 crossbred cows each year tested for carry-over effects from weaning treatments (150, 210, or 270 d) and found none (Story et al., 2000). However, in this experiment, the weaning treatment assignment was not constant across years. Stalker et al. (2007) conducted a 4-yr experiment to determine effects of 3 different weaning dates, but cows were re-randomized to weaning treatment each year and carry over effects were not reported. Grings et al. (2005) also re-randomized weaning date treatment assignment each yr and reported no carry over effects. Additional data discussing the potential effects of weaning date may clarify long-term impacts on cow-calf production.

In general, calf birth BW is greater when dams are on a greater plane of nutrition during gestation (Bellows and Short, 1978; Stalker et al., 2007). Subsequent calf growth may also be impacted by dam nutritional plane. Stalker et al. (2007) found calf ADG increased linearly as weaning was delayed from mid-August to the end of November in a spring calving system. However, authors indicated ADG response in the later fall weaning dates may have been due to weather or differences in gut fill. On the other hand, pre-partum nutrient restriction of dams has also been shown to decrease calf BW at birth, decrease weaning rates, and decrease calf BW at weaning (Corah et al., 1975).

Another point to consider is post-weaning management of weaned calves will have a significant effect on interim growth compared to nursing calves. Calf weight and growth potential is also influenced by breed, age of dam, and sex (Basarab et al., 1986).

Although calves born to later weaned dams may have lighter birth BW, this may have minimal impact if weaning BW of calves is similar, depending on calf marketing and seasonal market fluctuations (Short et al., 1996).

Subsequent heifer performance. Limited research has focused on the long term effect of differing weaning dates on subsequent heifer calf value as a replacement female. Impacts of weaning date manipulation (seen as BW or BCS change) may be greater in younger females. In addition, heifer development programs may dictate the magnitude of BW and ADG response seen from previous weaning date. Story et al. (2000) weaned replacement heifers at 150, 210, or 270 d and found early weaned heifers had decreased BW at the remaining weaning dates, but BW was similar across all treatments just prior to breeding. Similarly, Sexten et al. (2005) weaned heifers at 89 or 232 d and found early weaning decreased BW until breeding, but percentage of heifers pubertal by 8 mo increased. Despite these differences, no effect of weaning date was observed on long term performance of replacement heifers, milk production, or first or second calf crop. It is likely that since calf weaning BW and ADG are highly correlated with milk production (Totusek et al., 1973) and replacement heifer milk production was similar across weaning treatment, calf performance was also similar.

Subsequent steer performance. Interestingly, Myers et al. (1999b) observed a 15 and 7% improvement in feedlot ADG when steer calves were weaned at 90 and 152 d

compared to 215 d. Feed efficiency was also improved linearly as steer weaning age decreased, but early weaned steers had greater total DMI because greater time on feed was required to harvest steers at a constant 12<sup>th</sup> rib fat endpoint. Similarly, Fluharty et al. (2000) found a 5% improvement in G:F when steers were weaned 100 d earlier than contemporaries. However, not all feedlot performance favors early weaning. Story et al. (2000) found steers weaned at 270 and 210 d had 15 and 8% improvement in ADG over early weaned steers (150 d), and late weaned steers (270 d) had the greatest DMI. In this study, feedlot entry BW increased with increasing days nursing, and days on feed decreased with increasing BW. In agreement with this, Stalker et al. (2007) observed early weaned steers entered the feedlot 38 kg lighter and consumed 0.5 kg/d less than late weaned steers. The primary difference between the feedlot performance data in these experiments is the feedlot entry BW. Animals entering the feedlot at a heavier BW, regardless of weaning treatments, are expected to consume more DM and be less efficient than lighter animals when harvested at a similar endpoint.

Weaning date manipulation appears to have minimal impact on carcass characteristics, when animals are harvested at a constant 12<sup>th</sup> rib fat thickness or data are adjusted to reflect similar 12<sup>th</sup> rib fat thickness. In the aforementioned experiments with steer feedlot data, Myers et al. (1999b) reported the greatest variation in weaning age (125 d), and no differences were observed for HCW, LM area, YG, marbling score or QG. These data are in general agreement with Story et al. (2000) and Stalker et al. (2007). Interestingly, Fluharty et al. (2000) found a 17% numeric decrease in percentage carcasses low Choice or greater when steers were early weaned, compared to normal

weaning. This is in contrast to Myers et al. (1999a) who observed a 0.3 unit numerically lower YG when steers were early weaned.

Economics. Differences in reproduction and calf performance may impact the productivity of each separate segment of cow-calf production, as well as overall profitability of the system. When steers were harvested a constant 12<sup>th</sup> rib fat thickness, Story et al. (2000) found no effect of time of weaning on net income per animal. However, because heifers in this system were developed in a dry-lot after weaning, total costs of production were higher for early weaned females. In addition, weaning dams 150 d post-partum, reduced annual cow costs by \$33.36 and \$11.26 compared to dams weaned at 210 and 270 d, respectively. However, marketing lighter BW, early weaned calves may result in fewer net returns even though market prices are usually elevated at this time (Stalker et al., 2007). Economic return for each system is influenced by cow costs, heifer development costs, as well as feeder and fat cattle prices, which all need to be considered when management decisions are made.

A bio-economic model that simulated cow-calf range production revealed increasing calf age may improve range efficiency and profitability (Julien and Tess, 2002). Researchers used weaning BW per cow exposed as an economic measure of cow reproduction, calf mortality, and calf weaning BW. Delaying weaning increased weaning BW per cow exposed. Although early weaning decreased feed costs and saved forage resources, this benefit was negated by decreased weaning BW and lower calf sale values (calf marketing occurred at weaning). Breakeven steer price was also decreased when range removal date was extended by weaning later in the yr.

Grazed forage requirements also change when weaning date is adjusted to earlier or later in the season. In a fall calving herd, early weaned dams were estimated to consume 45.3% less forage than their nursing contemporaries; and cow-calf pairs weaned early consumed 20.4% less TDN than cow-calf pairs weaned at a more traditional date (Peterson et al., 1987). Purvis et al. (1996) evaluated early weaning fall-calving cows, and found post-partum (130 to 240 d after calving) forage DMI of early weaned cows was approximately 20 % less than dams weaned at a more traditional time. Calf intake constitutes a portion of this change in forage demand as well. This is important to consider because milk production and forage protein analyses suggest milk alone may not meet the metabolizable protein needs of the growing calf (Lardy et al., 2004). Clearly, early weaning decreases forage resources needed for cows; but, additional feed resources may be required to develop newly weaned calves, if backgrounding is an integral part of the production system.

## Winter grazing and third trimester supplementation

In addition to managing cow body reserves through early weaning, pre-partum nutritional plane can be improved through strategic use of higher quality feedstuffs. With abundant corn production in Nebraska, corn crop residues and DGS offer cow-calf production systems valuable resources during times when native range does not sufficiently meet cow requirements. Fortunately, corn residue rental rates and DGS prices are often economically competitive with other alternative feed resources.

**Cow - calf performance.** A 3-yr experiment evaluated a traditional production system (spring calving cows fed hay during winter) to an extensive forage utilization

production system (cows grazed corn residue during winter; Anderson et al., 2005).

After winter, cows fed hay had greater BW and BCS than cows on corn residue, but subsequent pregnancy rates were similar. Larson et al. (2009) also found similar pregnancy rates when dams grazed winter range or corn residue during the last trimester of pregnancy; however, dams on corn residue had greater BW and BCS after winter.

Anderson et al. (2005) attributed the difference in BW and BCS at pre-calving to greater forage quality and quantity of hay fed to dams on corn residue.

Previous research in the Nebraska Sandhills found the first limiting nutrient of cows grazing winter range is RDP (Lardy et al., 1999), which can limit microbial protein production when deficient (Karges et al., 1990). A follow up experiment found that only 0.14 kg DM/animal daily of supplemental RDP is necessary to maintain BW and BCS of gestating cows during winter (Hollingsworth-Jenkins et al., 1996). This supplementation level has been substantiated in several subsequent experiments (Stalker et al., 2006; Stalker et al., 2007; Larson et al., 2009).

Subsequent pregnancy rates may be unaffected by supplementing protein, even at this critical level. This is likely because non-supplemented cows are managed to maintain a moderate BCS, or basal diets provided (native range or hay) are of high enough quality such that reproduction appears unchanged. Freetly et al. (2000) demonstrated this when cows calving at a moderate BCS received treatments changing body reserves during the third trimester showed no differences in subsequent pregnancy rate. Likewise, pregnancy rates were similar between dams' supplemented pre-partum and those not supplemented in a spring calving system (Stalker et al., 2006, 2007). In

agreement with this, Larson et al. (2009) observed similar pregnancy rates between cows wintered on range or corn residue that were supplemented or not supplemented 90 d prior to parturition.

Interestingly, Stalker et al. (2006) found that calves born to dams fed supplement were born 3 d later than calves born to non-supplemented dams. Larson et al. (2009) observed a 5 d delay in calving if dams were supplemented on winter range. Treatments in Stalker et al. (2006) were arranged in a switch-back design; therefore cows did not remain on the same pre-partum supplement treatment each year. Cows from Larson et al (2009) remained on the same treatment for 3 yr, suggesting ongoing nutritional stress will advance calving date. Moreover, Larson et al. (2009) also found non-supplemented dams on winter range had the lowest incidence of calving within the first 21 d, further implicating the negative impact of nutritional stress. Still, Stalker et al. (2007) observed no difference in calving day when dams were supplemented or not supplemented prepartum, in a similar production system.

While fetal growth is greatest during the last trimester of gestation, undernutrition of the dam at this time does not consistently reduce calf birth BW. Bellows et al. (1978) fed pregnant dams high or low TDN rations 90 d prior to calving and found no effect on calf birth BW. Similarly, Stalker et al. (2006) observed similar calf birth BW when dams were supplemented or not-supplemented with a protein source approximately 90 d pre-calving. On the other hand, earlier research indicates energy restriction prior to parturition will increase calf birth BW (Corah et al., 1975; Houghton et al., 1990). This was substantiated more recently by Stalker et al. (2007) who fed dams supplemental

protein during the last trimester of gestation and increased calf birth BW by 2 kg; however, this difference was small. Wintering dams on corn residue rather than dormant range 90 d prior to parturition has also been shown to increase subsequent calf birth BW of steers (Larson et al., 2009), and tended to increase birth BW of heifers born from the same population of cows (Funston et al., 2010).

Calf health may also be affected by nutritional status of the dam. Corah et al. (1975) found a 7% increase in neonatal calf survival if dams were on a high energy diet during the last 100 d of gestation. This is in agreement with Stalker et al. (2006) who found increased percentage live calves at weaning when supplemented dams were compared to non-supplemented dams. Notably, Larson et al. (2009) observed a greater incidence of treatment for respiratory illnesses during finishing when steers were born to dams not receiving supplement prior to calving, compared to steers born to supplemented dams. Authors reported late gestation maternal nutrition did affect calf health prior to weaning.

Subsequent heifer performance. In Funston et al. (2010), heifer progeny born to dams grazing corn residue and supplemented with protein in the third trimester of pregnancy were the highest nourished, and heifer progeny born to dams grazing winter range without protein supplement in the last trimester of pregnancy were the lowest nourished. In this experiment, neither supplementation nor winter grazing system affected heifer progeny ADG from weaning to breeding. These heifers were individually fed (89 d) prior to the first breeding season and data suggested heifers born to highly

nourished dams have a tendency for lower G:F. Similarly, Martin et al. (2007) reported no effect of dam nutrition on heifer progeny ADG or G:F.

Funston et al. (2010) observed supplementation of dams during late gestation may lower heifer progeny age at puberty; whereas, dams wintered on range or corn residue produce heifer progeny with similar age at puberty. However, maternal protein and energy restriction does not always delay age at puberty of heifer progeny. Martin et al. (2007) found no effect of dam nutrition on percentage of heifers exhibiting ovarian luteal activity prior to breeding or pubertal age. In agreement with this, Corah et al. (1975) observed no difference in age at puberty of heifers born to dams severely restricted during the last 100 d of gestation compared to non-restricted dams. Based on the wide range of restriction applied to dams during late gestation in Corah et al. (1975) and Martin et al. (2007), it is doubtful that pubertal age of heifer progeny is predictably affected.

Heifers born to dams supplemented during the last trimester of pregnancy have greater BW post-weaning than contemporaries born to non-supplemented dams, which may be maintained through 3 yr of age (Martin et al., 2007); however BCS will likely be unaffected (Funston et al., 2010). Nonetheless, pregnancy rate of first calf heifers may be decreased by 10 to 13% if their dams are not supplied with adequate nutrition (Funston et al., 2010; Martin et al., 2007). However, data through the second breeding season of females born to dams under protein and energy restriction indicate pregnancy rates will be similar, regardless of maternal nutrition during late gestation (Funston et al. 2010). Martin et al. (2007) found a higher percentage of heifers born to dams supplemented with

protein during the last 90 d of pregnancy calved in the first 21 d of their first calving season. This is in contrast to Funston et al. (2010) who observed no difference in proportion of heifers calving in the first 21 d when dams were supplemented or not supplemented, and wintered on range or corn residue. Late gestation supplementation of dams has been shown to have little effect on calving date, calf birth BW, and calf weaning BW of heifer progeny (Martin et al., 2007; and Funston et al., 2010).

Subsequent steer performance. Larson et al. (2009) found steers born to dams wintered on range without supplemental protein were lighter at weaning and feedlot entry than steers born to dams receiving protein on dormant range. In this same experiment, dams were also wintered on corn residue, and protein supplementation had no effect on weaning or feedlot entry BW of steer progeny. Because cattle were fed the same number of days, the same patterns were seen in final BW, with no differences in feedlot DMI, ADG, and G:F. No effect of pre-partum supplementation of dams on steer progeny DMI, ADG, or G:F during finishing was also observed by Stalker et al. (2006). Stalker et al. (2007) found steers born to dams receiving protein supplement on dormant range during the last trimester of gestation entered and exited the feedlot at heavier BW. Because of the additional BW, steers born to supplemented dams had greater DMI and ADG, but G:F was similar. Summers et al. (2011) found spring calving cows receiving supplement during winter improved steer feedlot performance in yr 1, but did not impact ADG, DMI, G:F or final BW in yr 2.

Greater prenatal nutrition may also affect carcass weight and composition.

Carcass data adjusted to a constant 12<sup>th</sup> rib fat thickness indicate HCW and marbling

score are greater for steers born to dams receiving pre-partum supplement (Stalker et al., 2007). Larson et al. (2009) found a tendency for steers from protein supplemented dams to produce heavier carcasses. However, it is likely the difference in HCW in this trial was due to BW differences at the start of finishing. Loin muscle area was similar across all treatments in these two experiments. Interestingly, marbling score was not affected by wintering system (corn residue vs winter range) in Larson et al. (2009), but was greater for steers born to dams supplemented during the third trimester of gestation. The likelihood a carcass graded low Choice or better was 15.8% greater if the steers was born to a protein supplemented dam rather than a non-supplemented dam; with no differences between wintering systems. Summers et al. (2011) observed greater marbling scores in steer progeny born to supplemented dams, compared to non-supplemented dams. Conversely, Stalker et al. (2006) found no differences in any carcass characteristics between steers born to dams with and without pre-partum supplementation. Fetal programming effects of late gestation nutrition on progeny growth and composition are likely. Across domestic livestock species, intrauterine growth restriction caused from inadequate maternal nutrition decreases feed efficiency, increases whole-body and intramuscular fat and decreases meat quality of progeny (Wu et al., 2006). Nonetheless, predictable responses of beef cattle are not reported in the literature, indicating the extent of these effects is not well understood.

**Economics.** In a spring calving system, cows grazing corn residue during winter may have lower cost per weaned calf and weaning breakeven prices because feed costs are lower than feeding harvested forages throughout winter (Anderson et al., 2005). On

the other hand, Funston et al. (2010) observed developing dams on corn residue during late gestation increased heifer developments costs as much as \$19.41/pregnant heifer. Data from the same management system indicate wintering cows on corn residue may increase the value of weaned steers and net returns at weaning; but these price advantages are not seen in the finishing phase, or when the overall system was evaluated. Therefore, it may be advisable to sell steer calves at weaning without retaining ownership.

Stalker et al. (2006) reported increased net returns at weaning when calves were born to dams receiving pre-partum supplement, due to increased weaning BW and percentage live calves at weaning. Conversely, increased costs associated with supplement and delivery may be greater than the value of additional weight sold, resulting in decreased net returns at weaning (Larson et al., 2009). Funston et al. (2010) suggested protein supplementation of dams during late gestation increased heifer developments costs as much as \$30.42/pregnant heifer. It has been suggested that retaining ownership of steers born to protein supplemented dams through harvest will result in the greatest increase in net returns, because BW advantage is more likely to be realized at this point (Stalker et al., 2007). This is in agreement with Larson et al. (2009) who attributed increased percentage Choice carcasses and HCW to a \$30.00/animal advantage in net feedlot return of steers born to dams receiving protein supplement, compared to steers from non-supplemented dams. Still, negligible differences in net returns through finishing have been reported (Stalker et al. 2006). Clearly, economic calculations are complex because they are affected by different production scenarios, and dynamic markets, and are difficult to compare. Inconsistencies seen in economic data are usually a reflection of biological differences and/or variations in assumptions used in calculations.

## **Summary**

Within a given production system, cattle may be supplemented for several reasons: correct a nutrient deficiency, conserve forage, improve animal performance, or improve profitability. Distillers grains fit very well into high forage systems because they provide P, RUP, and additional energy. Distillers grains have proven to be an attractive option for supplementation programs because they are valued at approximately 70 to 90% the price of corn and decreased cattle on feed during summer months typically lower demand for DGS. Animal performance data show increased ADG and BW of cattle supplemented with DGS over non-supplemented cattle.

Cattle are sorted in the feedlot to produce a more uniform lot at the time of harvest. In general, the closer to harvest predictive measurements are taken, the better the measurements are at predicting carcass composition and one of the easiest methods to predict animal performance is by measuring BW. Although the benefits of sorting cattle have not shown consistent increases in profitability, biologically and economically, cattle should benefit from additional time on feed until the costs of production outweigh the additional value of added weight sold.

Nutrient requirements of cattle increase during times of physiological change, especially when the greatest amount of fetal growth occurs during late gestation period. Parturition has been identified as a critical point to achieve adequate body reserves for optimal reproduction and pre-weaning calf. The synchrony of cow requirements with

forage nutrients has been recommended as a management technique to efficiently develop and maintain forage based production systems. If done correctly, cattle will receive a majority of nutrients required from grazed forages. Although several resources are available to better align requirements with resources available, in-utero nutritional stresses play pivotal role in subsequent cow-calf performance. Under-nutrition causes suboptimal conditions in the maternal uterine environment which translates into depressed growth efficiency and negative impacts on body composition. Focusing on specific management practices may be the most practical approach for beef cattle research to evaluate these interactions from a systems context.

Adjustment of weaning date is a viable method to extend grazing season; thus, decreasing total purchased forage needs. Additionally, early weaning cows will lower nutrient requirements, increase BCS, and increase BW prior to calving. This critical point is especially important in a spring calving system because dormant forages often do not supply adequate nourishment to gestating cows. Although early weaning decreased feed costs and saved forage resources, this benefit was negated by decreased weaning BW and lower calf sale values at weaning. Grazed forage requirements also change when weaning date is adjusted to earlier or later in the season. Early weaning decreases forage resources needed for cows; but, additional feed resources may be required to develop newly weaned calves, if backgrounding is an integral part of the production system.

In addition to managing cow body reserves through early weaning, pre-partum nutritional plane can be improved through strategic use of higher quality feedstuffs. With

abundant corn production in Nebraska, corn crop residues and DGS offer cow-calf production systems valuable resources during times when native range does not sufficiently meet cow requirements. Fortunately, corn residue rental rates and DGS prices are often economically competitive with other alternative feed resources.

Subsequent pregnancy rates may be unaffected by supplementation if cows are managed to maintain a moderate BCS, or basal diets provided are of high enough quality such that reproduction appears unchanged. Intrauterine growth restriction caused from inadequate maternal nutrition decreases feed efficiency, increases whole-body and intramuscular fat, decreases meat quality of progeny (Wu et al., 2006), and has been implicated to increase pubertal age and decrease reproduction of female progeny (Funston et al., 2010a). It has been suggested that retaining ownership of steers born to protein supplemented dams through harvest will result in the greatest increase in net returns, because BW advantage is more likely to be realized at this point.

## **Objectives**

The research objectives presented herein were to evaluate effects of summer supplementation of long yearling cattle, determine the impact of subsequent feedlot sorting on BW, determine if weaning date and third trimester supplementation or grazing system effect cow-calf production and subsequent progeny performance, as well as identify and evaluate any interactions among the cow-calf management treatments. A 3-yr forage based systems experiment was conducted using long yearling steers to test the biological and economic effects of supplementing MDGS during summer on native Sandhills range. If summer gain can be achieved at a lower cost than subsequent feedlot

gain without sacrificing carcass quality, producers may have the opportunity to save money using a similar system. An ongoing 3-yr experiment using a spring calving cow herd in the Nebraska Sandhills will evaluate long-term effects of pre-partum supplementation on cow reproduction, heifer progeny growth and reproduction, and steer progeny growth, feedlot performance, and carcass characteristics. Early weaning, wintering on corn residue, and offering supplemental protein during late gestation may increase cow condition prior to calving and improve prenatal development of progeny. If achieved, producers may experience production and economic benefits such as decreased forage inputs, improved cow reproduction and herd maintenance, increased value of calves at weaning, decreased heifer development costs, and/or improved feedlot performance and profitability.

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# **CHAPTER II**

Summer supplementation and subsequent feedlot sorting of yearling steers<sup>1</sup>

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Division, supported in part by funds provided through the Hatch Act.

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<sup>&</sup>lt;sup>1</sup>This work is a contribution of the University of Nebraska Agricultural Research

## **ABSTRACT**

Effects of supplementing modified wet distillers grains with solubles (MDGS) during summer and subsequent feedlot sorting on yearling steer performance were evaluated. Each yr of a 3-yr study, 240 crossbred steers (initial BW =  $226 \pm 9$  kg) were used in a completely randomized design with a 2 x 2 factorial treatment arrangement. At the time of summer grazing (136 d), steers were assigned randomly to 1 of 2 treatments: 1) grazing native range with no supplement (CON); or 2) grazing native range with MDGS supplementation at 0.6% BW (DM; SUPP). After summer, steers were assigned randomly within grazing treatment to 1 of 2 feedlot sorting treatments: 1) sorted 3 ways based on distribution of feedlot entry BW (25% light, 50% medium, 25% heavy; **SORT**); or 2) not sorted, but serially harvested in 2 groups to allow for retrospective adjustment to a constant endpoint (NOSORT). During summer grazing, SUPP had 0.30 kg greater (P < 0.01) ADG and were \$9.81/steer more (P = 0.02) profitable than CON. At feedlot entry, SUPP were 48 kg heavier (P < 0.01) than CON. Feedlot ADG tended to be greater (P = 0.07) for CON than SUPP, but G:F and DMI were not different (P > 0.16). Supplemented steers were fed 24 d less (P < 0.01) to reach a similar  $12^{th}$  rib fat thickness as CON, had greater (P = 0.01) LM area, and lower (P < 0.01) marbling. Overall system economics revealed SUPP tended (P = 0.06) to be more profitable than CON when sold live and was \$18.14/steer more (P < 0.01) profitable when marketed on a grid. Sorting on feedlot entry BW increased (P < 0.05) HCW 5 kg for SORT compared to NOSORT; but percentage carcasses over 454 kg was similar (P = 0.80). Feedlot and overall system profitability was not different (P > 0.35) between sorting treatments. Supplemental

MDGS increases cattle gain during summer grazing, decreases days fed in the feedlot, and improves overall profitability of this system. Sorting yearling steers on feedlot entry BW increases weight sold at harvest.

**Key words:** yearling steers, supplementation, distiller grains, sorting, economics

# INTRODUCTION

Volatile markets and increased commodity prices have made forage based production systems increasingly attractive (Winterholler et al., 2008). Co-products of the corn dry milling industry fit well into forage feeding programs because distillers grains provide a highly fermentable fiber source that does not negatively impact forage digestion (Loy et al., 2008; Leupp et al., 2009). Distillers grains also supply additional RUP to meet metabolizable protein deficiencies common in lighter BW cattle grazing forage (Creighton et al., 2003), caused mainly by the high rumen degradability of forage protein (Buckner et al., 2011). Supplementing wet distillers grains with solubles (WDGS) or dried distillers grains with solubles (DDGS) to cattle on forage based diets or grazing pasture has been shown to increase ADG and BW with increasing levels of distillers grains supplemented (Morris et al., 2005, 2006; MacDonald et al., 2007; Jenkins et al., 2009). Demand for distillers grains is usually lower during summer due to decreased cattle on feed, resulting in reduced prices.

Added BW achieved through DGS supplementation results in fewer days on feed required during finishing to reach an acceptable final BW or 12<sup>th</sup> rib fat thickness (Morris et al., 2006; Funston et al., 2007; Greenquist et al., 2009). However, increased BW of animals in extensive grazing systems may raise the potential for overweight carcasses

(Vieselmeyer, 1993). Sorting yearlings on feedlot entry BW may alleviate this problem by decreasing overweight carcasses up to 8 percent, compared to non-sorted steers (Folmer et al., 2008).

The objectives of this experiment were to evaluate the effects of supplementing modified wet distillers grains with solubles (MDGS) during summer grazing and subsequent feedlot sorting on performance and carcass characteristics of long yearling steers.

#### MATERIALS AND METHODS

All procedures and facilities utilized were approved by the University of Nebraska-Lincoln Institutional Animal Care and Use Committee. Each year of a 3-yr study, 240 crossbred steers (initial BW =  $226 \pm 9$  kg) were utilized in a completely randomized design with treatments arranged in a 2 x 2 factorial design. At the time of summer grazing, steers were assigned randomly to 1 of 2 treatments: 1) grazing native range with no supplementation (**CON**); or 2) grazing native range with MDGS supplementation at 0.6% BW (DM; **SUPP**). After summer grazing, steers were assigned randomly within grazing treatment to 1 of 2 feedlot sorting treatments: 1) sorted 3 ways based on distribution of feedlot entry BW (**SORT**); or 2) not sorted (**NOSORT**). Within year, 30-animal groups (2 feedlot pens) served as the experimental unit. Each combination of summer grazing and feedlot sorting treatments consisted of 2 replicates within yr. Within summer grazing treatment, each replicate of the SORT steers were sorted into light, medium, and heavy BW groups 25% light, 50% medium, 25% heavy);

whereas each replicate of NOSORT steers was serially harvested in an early and late group (50% early, 50% late), to allow for retrospective adjustment of cattle to a constant endpoint.

## Winter

Each fall, within 24 h of arrival at the University of Nebraska Agricultural Research and Development Center (near Mead, NE), steers were vaccinated against *Infectious Bovine Rinotracheitis, Bovine Viral Diarrhea, Parainfluenza-3* and *Bovine Respiratory Syncytial Virus* (Bovi-Shield Gold 5; Pfizer Animal Health, New York, NY) and *Histophilus somni*, (Somubac; Pfizer Animal Health, New York, NY); administered a parasiticide (Dectomax, Pfizer Animal Health, New York, NY); and BW was collected at initial receiving (assumed as a shrunk BW). Directly after processing, steers were relocated to either cool season grass pastures or large feedlot pens where they were maintained as a common group for an average of 16 d. Steers were then reprocessed with a second dose of viral, bacterial, and clostridial vaccines (Bovi-Shield Gold 5, Ultrabac 7/Somubac, Pfizer Animal Health, New York, NY), and dosed with Pilliguard Pinkeye-1 (Durvet Animal Health Inc., Blue Springs, MO) to prevent against *Moraxella Bovis*.

After re-vaccination, steers were backgrounded as a common group on corn residue at the ARDC from late fall to mid-spring (145 d). While grazing corn residue, calves were supplemented with 2.27 kg DM/animal daily Sweet Bran (**SB**; Cargill, Blair, NE) and 0.11 kg DM/animal daily supplement formulated to provide 200 mg/animal daily monensin (Rumensin; Elanco Animal Health, Greenfield, IN). The basis for the winter grazing management system was established by Jordon (2000), who found a minimum

ADG of 0.68 kg was achieved at this feeding level. Corn residue forage was not limiting at any time during winter backgrounding. After corn residue backgrounding, steers were limit fed a diet of 50% alfalfa and 50% SB (DM) at 1.8% BW (DM) for 5 d. Initial BW for summer grazing was the mean of weights taken on 2 consecutive days in an effort to reduce variation in BW (Stock et al., 1983).

#### Summer

About April 15 each yr, calves were implanted with Revalor G (40 mg trenbolone acetate and 8 mg estradiol; Intervet Inc., Millsboro, DE); administered Phonectin (Teva Animal Health, St. Joseph, MO) for control against *Ostertagia ostertagi*, *Oesophagostomum radiatum, Haemonchus placei, Trichostrongylus axei, Cooperia punctate, Cooperia oncophora, and Haematobia irritans*; dosed with Pilliguard Pinkeye-1 (Durvet Animal Health Inc., Blue Springs, MO) to prevent *Moraxella Bovis* infection; weighed; stratified by BW; and assigned to summer grazing treatments. Steers were relocated on the University facilities and allowed to graze smooth bromegrass pastures for approximately 23 d and managed as a common group. After grazing brome, steers were transported to the University of Nebraska Barta Brothers Ranch (near Rose, NE) to graze native Sandhills range where summer grazing treatments were applied and they were managed as 2 separate groups accordingly. The basis for the supplement level was set by Morris et al. (2005, 2006), who found improved ADG and complete consumption of DDGS supplement at 0.5% BW of yearlings grazing similar range.

Within year, BW were projected using predicted ADG each month for determination of summer grazing supplementation amounts; therefore, MDGS

supplementation ranged from 2.0 to 2.5 kg DM/animal daily throughout the grazing period. Modified wet distillers grains with solubles was procured from 1 source prior to cattle arrival and stored on the ground in a plastic silo bag. Each yr, weekly MDGS samples were obtained, frozen, and stored for subsequent analysis of dry matter and nutrient composition (Table 1). Modified wet distillers grains with solubles was fed 6 d/wk on the ground with a tractor and feed wagon, allowing steers to be distributed to different locations within each pasture at the time of feeding. During summer grazing (136 d), steers had *ad libitum* access to trace mineralized salt.

Temperatures in this area (Ainsworth, NE) ranged between a low of 6.4°C in May to a high of 29.8°C in August; and annual precipitation for the 3 yr experiment averaged 65.6 cm (NCDC, 2011). Dominant plant species at the Barta Brothers Ranch were described in detail in Buckner et al. (2011). Across the 3 yr of the experiment, SUPP steers were stocked in pastures at 1.19 AUM/ha and CON steers were stocked in pastures at 1.40 AUM/ha. Steers were rotated among 8 pastures so forage quantity did not limit animal performance at any time during summer grazing.

## Finishing

Mid-September each year, steers were transported to the University of Nebraska Agricultural Research and Development Center, re-implanted with Revalor S (120 mg trenbolone acetate and 24 mg estradiol; Intervet Inc., Millsboro, DE), administered Phonectin (Teva Animal Health, St. Joseph, MO) for internal and external parasitic control, and placed into pens (15 animals/pen). Upon feedlot entry, steers were adapted to a common finishing diet in 17 d by decreasing roughage from 45 to 5% (DM) and

replacing it with high moisture corn. The finishing diet contained 50% high moisture corn, 40% SB, 5% wheat straw, and 5% dry supplement. The diet was formulated to provide 405 mg/animal daily monensin (Elanco Animal Health, Greenfield, IN) and 90 mg/animal daily tylosin (Elanco Animal Health, Greenfield, IN) assuming a 12.3 kg DMI; and to meet or exceed NRC (1996) requirements for metabolizable protein, Ca, P, and K.

The basis for the feedlot sorting strategy was established by MacDonald et al. (2006), who suggested sorting yearlings into 3 marketing groups on feedlot entry BW. Days fed for SORT steers were based on previous research, which estimated when overweight carcasses were produced by a similar type of cattle (Folmer et al., 2008; Griffin et al., 2009). Non-supplemented steers on the SORT treatment were fed for 147, 133, and 119 d, for the light, medium, and heavy BW groups, respectively. Whereas, SUPP steers on the SORT treatment in the light, medium, and heavy BW groups were fed for 126, 112, and 91 d, respectively.

Steers on the NOSORT treatment were serially harvested to allow for retrospective adjustment of cattle to a constant harvest endpoint. Days fed for NOSORT steers were based on previous research, which serially harvested a similar type of cattle (Vieselmeyer, 1993). Non-supplemented steers on the NOSORT treatment were fed for 119 and 133 d, for the early and late serial harvest groups, respectively. Supplemented steers on the NOSORT treatment in the early and late serial harvest groups were fed for 91 and 112 d, respectively. Based on BW differences at the end of summer grazing, days

on feed for CON and SUPP steers within feedlot sorting treatment were adjusted to produce carcasses with similar 12<sup>th</sup> rib fat thickness.

#### Carcass Characteristics

The same commercial abattoir (Greater Omaha Packing Co., Omaha, NE) was used for harvest across yr. Liver scores and HCW were obtained at harvest. Final BW was calculated from HCW and an assumed DP (63%). All carcass data were collected after a 48-h chill. Trained personnel measured LM area and 12<sup>th</sup> rib fat thickness; USDA graders determined marbling score. Calculated YG was determined as follows (Boggs and Merkel, 1993):

Calculated YG =  $(2.5 + (5.51 \text{ x } 12\text{th rib fat thickness, cm}) - (0.70 \text{ x LM area, cm}^2) + (0.2 \text{ x KPH}) + (0.0084 \text{ x HCW, kg})),$ 

where:

KPH was estimated at a constant 2.5%.

# **Economic Analyses**

An enterprise budget was created to illustrate economic implications of supplementation during summer grazing and sorting on feedlot entry BW. Economic analyses were based on price averages from 2006 to 2010 using the month(s) cattle were bought or sold, and feed ingredients were used. Total cost for each phase of production included initial steer cost, steer interest, feed cost, feed interest, variable costs, and variable cost interest. Variable costs included yardage, veterinary/processing fee, death loss, transportation, and marketing/risk management fee. Agricultural operating loan interest rates from the Federal Reserve Bank of Kansas City averaged 7.61% for

Nebraska (Federal Reserve, 2011). To prevent errors associated with cyclic calculations, an average calf interest was determined within production phase and included in subsequent analysis. Veterinary and processing fees charged were \$8.33/animal for each production phase. Transportation rates were \$4.00/loaded 1.61 km with distance to winter pasture at 16.09 km, distance to summer pasture at 80.47 km, and distance to abattoir at 80.47 km. These distances remained constant across all treatments and were chosen to reflect scenarios representative of Nebraska producers. Marketing and risk management costs were assumed to be \$0.25/45.4 kg of BW sold for each production phase. Revenue for each phase of production was sales price of the animal. Profit or loss was determined by subtracting total costs for each phase of production from revenue from the respective phase of production. Cost of gain (COG) was determined for each phase of production by dividing steer interest, feed, feed interest, variable costs, and variable interest by BW gain for the respective phase of production. Breakeven sales price (BE) for each phase of production was determined by dividing total cost by BW at the end of the respective phase of production.

*Winter*. Corn residue was charged at \$0.12/animal daily, which was the actual price paid during the experiment. Steers were fed 2.27 and 0.11 kg DM/animal daily SB and dry supplement that cost \$137.40/908 kg DM (95% corn price; USDA, 2011b) and \$190.00/908 kg DM, respectively. When steers grazed corn residue, yardage was included at \$0.25/animal daily, which included delivery of SB and supplement. A death loss of 1.5% of the winter purchase price was also included. Interest was charged for the corn residue grazing period for corn residue rental rate, SB, supplement, yardage, death

loss, and \$8.33/animal veterinary and processing fees. Feeder cattle price at entry into the winter phase was \$121.28/45.4 kg (USDA, 2011f) and \$110.50/45.4 kg (USDA, 2011f) at the end of the winter phase. Interest of steers during the winter phase averaged \$17.75/animal.

Summer. Using the average regional pasture rental rate of \$31.84/AUM (590 kg; Johnson et al., 2010), NRC energy equations to estimate forage DMI (NRC, 1996), and forage replacement of 17% (Watson, 2010) for SUPP steers compared to CON steers; annual summer pasture rental rates were included at \$0.41/animal daily and \$0.49/animal daily for SUPP and CON steers, respectively. Steers supplemented at 0.6% BW were charged \$111.69/908 kg DM (75% corn price; USDA, 2011b)) for MDGS; whereas, CON steers were not charged any additional feed costs. Yardage for CON steers was included at \$0.10/animal daily during the summer phase and yardage for SUPP steers was included at \$0.20/animal daily. The additional yardage assigned to SUPP steers over CON steers during summer grazing accounted for MDGS delivery. A death loss of 0.5% of the summer purchase price was also included. Interest was charged for the summer grazing period for pasture rent, MDGS (SUPP steers only), yardage, death loss, and \$8.33/animal veterinary and processing fees. Feeder cattle price at entry into the summer phase was \$110.50/45.4 kg (USDA, 2011f) and \$104.36/45.4 kg (USDA, 2011f) at the end of the summer phase. Because SUPP steers were heavier than CON steers after summer grazing, a \$5.10/45.4 kg price slide (Dhuyvetter et al., 2001) was used to adjust the price of steers after summer grazing. Interest of steers during the summer phase averaged \$25.73/animal and was added to winter calf interest.

*Finishing*. The finishing diet for all steers was 50% high moisture corn, 40% SB, 5% wheat straw, and 5% dry supplement. Therefore, corn was charged at \$3.74/25.4 kg DM (USDA, 2011b) + \$0.05/25.4 kg DM (corn processing; Macken et al., 2006), MDGS was charged at \$111.69/908 kg DM (75% corn price; USDA, 2011b), SB was charged at \$127.03/908 kg DM (95% corn price; USDA, 2011b), supplement was charged at \$190.00/908 kg DM, and wheat straw was charged at \$58.04/908 kg DM (USDA, 2010a). Yardage was included at \$0.45/animal daily for all animals during the feedlot phase. A death loss of 0.25% of the feedlot purchase price was also included. Interest was charged for finishing phase yardage, death loss, \$8.33/animal veterinary and processing fees, and half the finishing diet. Feeder cattle price at entry into the feedlot phase was \$104.36/45.4 kg (USDA, 2011f). Because SUPP steers were heavier than CON steers entering the feedlot, a \$5.10/45.4 kg price slide (Dhuyvetter et al., 2001) was used to adjust the price of steers at feedlot entry. Fed cattle were priced on a grid (Table 2; USDA, 2011c,d,e). Live fed cattle sales price was \$137.90/45.4 kg of HCW (USDA, 2011e). Interest of steers during the feedlot phase averaged \$25.03/animal, which was added to the sum of winter and summer calf interest.

*Overall.* Total cost of production included initial steer cost at the winter phase, steer interest accrued during the entire system, all feed costs, feed interest, all variable costs, and variable cost interest. Revenue was fed cattle sales price, determined on a live animal and grid basis. Steers in the CON - NOSORT treatment group were considered the most traditional long yearlings in this system and served as the control; thus, feeder

cattle price at entry into the winter phase was adjusted to produce a \$0.00 profit (breakeven) when the whole production system was assessed.

Price Comparison. To illustrate effects of supplementing with MDGS and sorting on feedlot entry BW in an increased price scenario, more current commodity and cattle prices were obtained (same sources as described above). Prices for the wk of 25 July 2011 were used for DRC (\$8.40/25.4 kg DM), MDGS (75% corn price; \$225.50/908 kg DM), SB (95% corn price; \$308.78/908 kg DM for the winter phase; \$284.80/908 kg DM for the feedlot phase), feeder cattle at entry into the winter phase (\$148.00/45.4 kg), feeder cattle at the end of the winter phase/entry into the summer phase (\$135.00/45.4 kg), feeder cattle at the end of the summer phase/entry into the feedlot phase (\$129.15/45.4 kg), and live fed cattle (\$108.38/45.4 kg of HCW). No adjustments were made to treatment groups to produce a \$0.00 profit (breakeven) when the entire system was assessed. All other prices, assumptions, and variables in the enterprise budget remained constant in the economic analyses with 26 July 2011 prices. By doing this, the economic effects of the biology of this long yearling production system were evaluated in 2 price scenarios.

# Statistical Analyses

Population distribution was considered normal for: BW, days on feed, ADG, DMI, G:F, LM area, 12<sup>th</sup> rib fat thickness, and marbling score. Fixed effects for each trait included summer grazing treatment, feedlot sorting treatment, and the interaction. Percentage HCW, percentage QG, and percentage CYG were analyzed as binomially distributed data. Random effects were year and residual error. Fixed effect interactions

with year were tested in preliminary analyses; however, they were removed from subsequent analyses because relative difference between summer grazing and feedlot sorting treatments remained similar across years. Data were analyzed using the GLIMMIX Procedure of SAS (SAS Inst. Inc., Cary, NC). Effects of treatment or the interaction were considered significant when P < 0.05 as detected by Fischer's test. When the F-test was significant, least square means of treatments were separated using a t-test when P < 0.05. Due to several interactions between effect of summer grazing and feedlot sorting treatments, data are reported as simple effects. Where an interaction is not present, main effects are discussed.

#### RESULTS AND DISCUSSION

#### Winter

There were no summer grazing by feedlot sorting treatment interactions in the winter (Table 3). Because steers were managed as a common group and no treatments were applied during winter grazing, initial BW, ending BW and ADG were not different (P > 0.14) due to summer grazing and feedlot sorting treatments. Steers gained 91 kg during the 145 d corn residue grazing period, or 0.65 kg/d.

# Summer

There were no summer grazing by feedlot sorting treatment interactions in the summer (Table 3). Body weight was similar (316 kg; P = 0.92) between SUPP and CON steers at the initiation of summer grazing. However at the end of summer grazing, SUPP steers were 48 kg heavier (P < 0.01) than CON steers. This is in agreement with Greenquist et al. (2009), who found steers grazing smooth bromegrass (157 d)

supplemented with DDGS at 0.6% BW were 37 kg heavier than non-supplemented control steers at the end of summer. Morris et al. (2006) grazed yearling steers on similar range during summer and observed a 16 kg BW advantage to supplementing DDGS at 0.5% BW for 84 d compared to not supplementing.

Supplemented steers had 0.30 kg greater (*P* < 0.01) ADG than CON steers during summer grazing. Protein analyses of diet samples collected from nearby summer pastures where the yearlings were maintained, indicated CON steers were deficient in RDP in August and September (Buckner et al., 2011). Because MDGS was fed in excess of metabolizable protein requirements, MDGS likely supplied sufficient RDP to SUPP steers. A 5-yr summary of yearling supplementation strategies on monoculture bromegrass pastures found the increased response of cattle to DDGS supplementation was not constant through the grazing season (Watson, 2010). Authors defined animal response to DDGS supplementation as the ratio of increased gain of supplemented animals to increased gain of non-supplemented animals. Interestingly, as digestibility of the bromegrass and ADG of the steers declined through the grazing season, supplementation response to DDGS increased from 0.15 to 0.34 kg/d; indicating supplementation during periods when forage quality (digestibility, TDN) are reduced may be favorable. Data from the current experiment support this hypothesis.

A meta-analysis conducted by Griffin et al. (2011) included 14 experiments where DDGS were fed in several different forage systems. Pastures contained cool and warm season grasses including smooth bromegrass, bermudagrass, and native Sandhills range. Authors found a quadratic ADG response to DDGS supplementation (y = 1.4736 + 1.4736

 $1.2705x - 0.5156x^2$ ). Figure 1 shows the meta-analysis quadratic response to ADG when supplementing DDGS, superimposed with the ADG for CON and SUPP steers from the current experiment. The ADG response to MDGS supplementation during summer grazing is in agreement with Griffin et al. (2011), where DDGS was utilized. This suggests the relative feeding value of DDGS and MDGS are similar in forage-based feeding programs. This is supported by Wilken et al. (2009), who found similar response in growing calves when fed DDGS or MDGS in 68% forage diets. In contrast, Nuttelman et al. (2011) observed decreased feeding value of distillers grains with decreasing moisture level in finishing diets. Cattle in Griffin et al. (2011) were supplemented with DDGS provided in a bunk; whereas, MDGS in the current experiment was fed directly on the ground. It has been estimated feeding WDGS on the ground results in 13 to 20% waste compared to feeding WDGS in a bunk (Musgrave et al., 2010). These data indicate MDGS may have a greater feeding value than DDGS because animal performance was similar without a correction for MDGS waste. Also, based on visual appraisal, feeding MDGS on the ground did not have a negative impact on native range.

Body weight and ADG were not different (P > 0.55) between SORT and NOSORT steers in the summer, because feedlot sorting treatments were not yet applied. *Finishing* 

A summer grazing by feedlot sorting treatment interaction (P < 0.01) in the feedlot phase was found for days on feed, but this was a consequence of treatment assignment (Table 4). Steers supplemented with MDGS during the summer phase

entered the feedlot 48 kg heavier (P < 0.01) than CON steers. Therefore, to reach a similar  $12^{th}$  rib fat thickness, SUPP steers required 24 fewer (P < 0.01) d in the feedlot compared to CON steers. Feedlot ADG tended to be greater (P = 0.07) for CON steers than SUPP steers, but G:F and DMI were not different (P > 0.16). Because feedlot harvest date was targeted to equal fat thickness between CON and SUPP steers, final BW was not different (P = 0.57) between CON and SUPP steers. These data indicate CON steers did not experience subsequent compensatory growth during the feedlot phase. This is in agreement with Funston et al. (2007), who found yearling cattle given ad libitum access to DDGS during summer grazing (53 d) entered the feedlot 27 kg heavier than non-supplemented contemporaries. To reach a similar final BW and 12<sup>th</sup> rib fat thickness, supplemented steers were fed 14 d less in the feedlot than steers not given access to DDGS; and no differences were observed for feedlot ADG, DMI or G:F. Similarly, in Morris et al. (2006), yearling steers were fed increasing levels of DDGS while grazing native Sandhills range during summer grazing. Regardless of prior supplementation treatment, steers had similar DMI, ADG, and G:F in the feedlot compared to non-supplemented steers. Greenquist et al. (2009) supplemented yearling steers on smooth bromegrass at 0.6% BW with DDGS, and also observed similar feedlot ADG with non-supplemented steers. These data suggest non-supplemented cattle do not exhibit subsequent compensatory gain in the feedlot. In contrast, non-supplemented calves had a 0.12 kg increase in feedlot ADG compared to DDGS supplemented calves (Lomas and Moyer, 2008).

By experimental design, SORT steers entered the feedlot at a similar (P = 0.79)BW as NOSORT steers within grazing treatment. However, SORT steers were fed 8 d longer (P < 0.01) than NOSORT steers. Steers not sorted on feedlot entry BW had 0.30 kg/d greater (P = 0.02) DMI than SORT steers; but ADG and G:F were similar (P > 0.02) 0.17). As a result of time on feed, final BW was 5 kg greater (P = 0.01) for SORT than NOSORT steers. Sorting heavier BW steers off for harvest allowed lighter BW animals to be fed longer and increased total weight sold for SORT steers. This is in agreement with MacDonald et al. (2006), who found yearling steers sorted on feedlot entry BW into 2 marketing endpoints were fed 7 d longer, and had 13 kg greater final BW than nonsorted steers. Folmer et al. (2008) evaluated effects of sorting cattle into 3 groups (25% light, 50% medium, 25% heavy) based on feedlot entry BW, compared to a non-sorted group, which is the same strategy utilized in the current experiment. As a result, sorted cattle were fed 6 d longer, had 9 kg greater final BW and 0.15 kg/d DMI than cattle not sorted. In contrast, Griffin et al. (2009) sorted cattle into groups of 32% heavy, 44% medium, and 24% light. Sorted steers were only fed 3 d longer than non-sorted steers. Feedlot ADG, DMI, G:F, and final BW were not different between sorted and non-sorted steers, likely because time on feed was not increased enough in the sorted steers to measure an animal response.

#### Carcass Characteristics

A summer grazing by feedlot sorting treatment interaction (P = 0.02) was found for marbling score (Table 4). Interestingly, CON - SORT steers had the greatest marbling score, CON - NOSORT steers were intermediate, and SUPP steers had the

lowest marbling score, regardless of feedlot sorting treatment. Marbling score for CON steers increased with increasing d fed, but this trend was not consistent with SUPP steers. Longissimus muscle area was greater (P = 0.01) for SUPP than CON steers. It is possible additional energy and metabolizable protein from MDGS fed to SUPP steers resulted in greater LM area, because CON steers were likely deficient in RDP (Buckner et al., 2011). Calculated yield grade was greater (P < 0.01) for CON steers than SUPP steers, which concurs with marbling score data. There was no effect (P > 0.63) of summer grazing treatment on liver scores.

Other carcass data show similar HCW, LM area, 12<sup>th</sup> rib fat thickness, marbling score, and YG of animals supplemented or not supplemented with DDGS (Morris et al., 2006; Funston et al., 2007). In agreement with this is Creighton et al. (2003), who observed no effect of summer RUP supplementation on carcass fatness, QG, or YG. However, other data suggest cattle supplemented with DDGS results in carcasses with greater intramuscular fat. Greenquist et al. (2009) and Watson (2010) observed greater marbling scores for supplemented than non-supplemented steers. Funston et al. (2007) found a tendency for DDGS creep fed steers to have a higher percentage grading choice when compared to steers without prior access to DDGS. Cattle fed finishing diets containing distillers grains may have altered lean and adipose tissue deposition (Koger et al., 2010; Schoonmaker et al., 2010).

Rate of change for carcass characteristics for NOSORT steers was determined by taking the difference in the response variable divided by the difference in days fed between late and early serial harvest dates (Table 5). Steers supplemented during

summer grazing had a 0.942 kg/d increase in HCW; whereas, HCW of CON steers increased at a lower rate of change (0.891 kg/d). Similarly, SUPP steers LM area increased at a rate of 0.142 cm<sup>2</sup>/d and CON steers LM area increased at a lower rate of 0.132 cm<sup>2</sup>/d. These data support the hypothesis that SUPP steers were supplied sufficient amounts of energy and metabolizable protein from MDGS, compared to CON because rate of change for LM area was greater. Rate of change per day for 12<sup>th</sup> rib fat thickness, marbling score, and CYG were also greater for SUPP (0.004, 3.065, and 0.022 units/d, respectively) than CON steers (-0.002, 1.858, and -0.001 units/d, respectively). Increase in HCW in Vieselmeyer (1993) was similar to CON - NOSORT steers in the current experiment. Fattening rates of change in the current experiment are also in agreement with Griffin et al. (2007), who observed 0.011 cm/d and 2.170 point/d for 12<sup>th</sup> rib fat thickness and marbling score, respectively. This is in contrast to other research suggesting a rate of change for marbling score of 0.0118 units/d (Vieselmeyer, 1993). Other experiments evaluating rate of change found greater fat deposition values for yearling cattle (May et al., 1992; Bruns and Pritchard, 2003; Griffin et al., 2009). Estimates of rate of change from the current experiment for marbling score and YG agree closely with May et al. (1992), who reported 3.55 and 0.018 units/d, respectively, for calf feds. However, in general, estimates for rate of change for all variables in the current experiment are lower than values reported in previous literature for yearlings.

Steers sorted on feedlot entry BW were 5 kg heavier (P = 0.01) at harvest than NOSORT steers. However, LM area and  $12^{th}$  rib fat thickness were not different (P > 0.21) between sort treatments. Marbling score and CYG were also greater (P < 0.05) for

SORT steers compared to NO SORT steers. Differences in HCW, marbling, and CYG are likely explained by the longer time on feed of SORT steers than NO SORT contemporaries. Sorted steers were on a finishing diet for 8 d more (P < 0.01) than NO SORT steers. Heavier BW steers were sorted off for harvest, leaving the lightest BW steers to be fed longer and allow time for additional HCW.

The increase in HCW was similar in Folmer et al. (2008), who observed a 6 kg increase in HCW when cattle were sorted. However, other research indicates sorting cattle on feedlot entry BW may not increase HCW (MacDonald et al., 2006; Griffin et al., 2009). Authors in MacDonald et al. (2006) attribute the lack of success with their sorting strategy to too few of sort groups to adequately separate weight groups of cattle. The sorting objective of increasing HCW in Griffin et al. (2009) may have been achieved if sorted cattle were fed more than 3 additional d compared to non-sorted steers. Previous research does not agree with increased marbling score and CYG of sorted cattle (Folmer et al., 2008; Griffin et al., 2009). In fact, sorted steers have been found to have lower USDA called YG than non-sorted steers (MacDonald et al., 2006).

Sorting cattle on feedlot entry BW did not (P = 0.80) reduce the percentage carcasses over 453 kg; however, a 2.4% numeric reduction in overweight (> 453 kg) carcasses was observed (Table 6). There was no effect (P > 0.35) of summer grazing or feedlot sorting treatments on frequency of QG; 13% steers graded Prime, 71% graded Upper 2/3 Choice, and 16% graded Low Choice. Numerically, CON steers had 14% more Prime carcasses than SUPP steers; and SORT steers had 7% more carcasses grade Prime compared to NOSORT steers. These differences are likely due to increased time

on feed. There was also no effect (P > 0.55) of summer grazing or feedlot sorting treatments on YG frequency, with 5% steers being YG 1, 34% YG 2, 49% YG 3, 11% YG 4, and 1% YG 5. This is in agreement with MacDonald et al. (2006) who were unable to increase HCW or reduce overweight or overfat carcasses when a 2 way sorting strategy was employed. However, Folmer et al. (2008) sorted yearling steers with the same 3 way split in BW as in the current experiment, and reduced overweight carcasses by over 8.0%. Moreover, variation analyses showed a 37.5% reduction in carcass weight variability when the 3 way sorting strategy was utilized. Griffin et al. (2009) also used a similar sorting strategy, but found no benefit to sorting yearling steers on feedlot entry BW because HCW and overweight carcasses were not reduced, while overfat carcasses increased.

#### **Economics**

*Winter.* There were no summer grazing by feedlot sorting treatment interactions in the winter (Table 7). Because steers were managed as a common group during the winter grazing, differences among summer grazing and feedlot sorting treatments were not observed (*P* > 0.14). Initial steer cost in the winter phase averaged \$524.25/animal. Corn residue rental rate for the 145 d backgrounding period was \$16.80/animal, SB supplementation at 2.27 kg DM cost \$48.09/animal, and supplement cost was \$3.33/animal. Yardage was \$35.00/animal, death loss was \$8.82/animal, transportation cost was \$0.96/animal, and risk management fees were \$1.75/animal. Total cost among summer grazing and feedlot sorting treatments averaged \$667.61/animal and steer value

averaged \$770.35/animal at the end of winter backgrounding. Therefore, the winter phase was profitable in this production system, with a profit of \$102.74/animal.

*Summer*. There were no summer grazing by feedlot sorting treatment interactions in the summer phase (Table 8). Feedlot sorting treatments were not applied until after summer; thus, treatment effects were not significant (P > 0.14). By experimental design, steer cost at the initiation of the summer phase was similar (P = 0.92) across summer grazing treatments and averaged \$770.35/animal. Due to estimated forage replacement of summer supplementation, pasture rent for SUPP steers was \$13.47/animal less than CON steers. Modified wet distillers grains with solubles cost \$44.77/animal for SUPP steers during the 136 d grazing period. Supplemental MDGS cost was greater than the forage replacement value, causing SUPP steers to have \$31.30/animal greater (P < 0.01) feed costs than CON steers.

Additional costs associated with delivering MDGS resulted in SUPP steers having \$16.04/animal greater (P < 0.01) yardage charges compared to CON steers. Because SUPP steers were 48 kg heavier than CON steers at the end of summer grazing, transportation cost and risk management fees during the summer phase were \$0.42 and \$0.26/animal greater (P < 0.01) for SUPP than CON steers, respectively. Total cost for SUPP steers averaged \$958.57/animal and was \$49.42/animal greater (P < 0.01) than CON steers. Additional feed costs from MDGS and yardage comprised approximately 64% and 33% of the total cost increase of SUPP over CON steers. Despite increased inputs, SUPP steers were \$8.96/animal more (P = 0.03) profitable than CON steers during summer because they had greater (P < 0.01) revenue from additional weight sold.

The 12% reduction (P < 0.01) in COG for SUPP compared to CON steers was expected due the energy density of the supplemental MDGS over native range. Morris et al. (2005) also observed a favorable economic response to supplementing DDGS versus not supplementing, but noted DDGS may be more valuable when supplemented with low quality than high quality forages. Data from the current experiment are in agreement with Morris et al. (2006) who found DDGS supplementation was profitable in a yearling production system due to increased BW sold at the end of summer grazing and decreased forage cost. Similarly, DDGS used as creep feed for yearlings in the Sandhills, was estimated to have \$24.08/metric ton greater overall value at the end of summer grazing than what is paid (Funston et al., 2007). Interestingly, Watson (2010) observed similar total costs between supplemented and non-supplemented steers in a bromegrass grazing system, but in that scenario, yardage was charged equally across treatments. Revenue was \$46.71/animal greater for supplemented than non-supplemented steers, resulting in greater profitability, lower COG and lower BE for supplemented animals, which agrees closely with these data.

*Finishing.* Summer grazing by feedlot sorting treatment interactions (P < 0.01) were found for yardage, variable cost, and variable cost with interest; but are a result of days on feed, which is a function of treatment assignment (Table 9). Because SUPP steers had additional BW after summer grazing, steer cost at the initiation of the feedlot phase was \$58.37/animal greater (P < 0.01) for SUPP than CON steers. However, less time on feed was required to finish SUPP steers; thus feed and yardage costs were \$48.06 and \$10.52/animal less (P < 0.01) compared to CON steers. Total cost while in the

feedlot was similar (P = 0.69) between summer grazing treatments, and averaged \$1371.41/animal. Live value of steers at harvest was also similar (P = 0.91) between CON and SUPP steers, since final BW was comparable, averaging \$1254.36/animal. When cattle were evaluated on a grid basis, there was no effect (P = 0.34) of summer grazing treatment, with steer value \$1262.29/animal. Profitability on a live and grid basis followed the same pattern as steer value, without an effect of summer grazing treatment (P > 0.32). Yearlings lost \$117.04/animal on a live basis, and lost \$109.12/animal on a grid during finishing. Steers lost \$7.92/animal less when valued on the grid vs. live because carcasses were awarded premiums for higher quality and yield, with similar final BW. Although yardage and feed costs were less for SUPP than CON steers, less total BW gain in the feedlot resulted in feedlot COG being \$4.02/animal greater (P < 0.01) for SUPP than CON steers. Morris et al. (2006) also observed increased profitability in the feedlot when yearlings were previously supplemented DDGS during summer grazing. Likewise, Funston et al. (2009) estimated the value of DDGS offered as a creep feed to yearlings in the Sandhills of NE to be \$15.44/metric ton greater at harvest than what was paid prior to summer.

By experimental design, steer cost at the initiation of the feedlot phase was similar across feedlot sorting treatments (P = 0.90) and averaged \$984.11/animal. More time on feed was required to finish lighter BW steers remaining after heavier BW steers were sorted off for harvest, which increased feed and yardage costs by \$9.33 and \$3.58/animal (P < 0.01) for SORT steers, compared to NOSORT steers. Transportation and marketing/risk management costs were also greater (P = 0.01) for SORT than NOSORT

steers due to greater final BW; thus, causing SORT steers to have \$13.99/animal greater (P < 0.01) total cost during finishing compared to NOSORT steers. When marketed live, SORT steers were \$18.42/animal more (P = 0.01) valuable than NOSORT steers. However, SORT steers only tended (P = 0.07) to be more valuable than NOSORT contemporaries when sold on a grid. These data indicate in this scenario, additional weight sold was more valuable than premiums obtained from value-based marketing. Despite this, increased costs associated with feeding cattle longer were greater than the value of the additional weight sold, and profitability in the feedlot phase was similar (P > 0.52) between feedlot sorting treatments. Thus, BE prices and feedlot COG were similar (P > 0.45) between SORT and NOSORT steers.

Feedlot profitability data are in contrast to Adams et al. (2010), who found fall yearlings were more profitable when marketed on a grid compared with live marketing. In that scenario, discounts for overweight carcasses exceeded the benefit from additional weight sold. Feedlot COG, BE, steer value, and profit or loss were not different between 3 way sorted and non-sorted yearlings in Griffin et al. (2009). In agreement with these data, Folmer et al. (2008) sorted steers 3 ways and observed greater total production costs, but BE and feedlot COG were similar with non-sorted yearlings. Although live value and grid value were \$14.74 and \$28.62/animal greater for sorted steers, profitability was not different between sorted and non-sorted steers because the increased costs of production with sorting were greater than the increased value. MacDonald et al. (2006) was also unable to improve profitability when cattle were sorted 2 ways on feedlot entry BW. It appears adjusting the sorting strategy from a 2 way sort to a 3 way sort does not

increase BW gain enough to overcome production costs. However, all 4 experiments found a numeric increase in profitability when a sorting strategy based on feedlot entry BW was used. Interestingly, a simulation analysis predicted discounts for overweight and YG 4 carcasses can reach as high as 15% of a feedlot pen and still not exceed the benefit of selling more weight and higher quality carcasses (Fuez et al., 2002). However, Fuez et al. (2002) suggested increasing time on feed by 14 d, and in the current experiment sorted cattle were fed only 8 d longer than non-sorted cattle. It is plausible to hypothesize if sorted cattle were fed an additional 6 d, feedlot profit would begin to favor sorting.

*Overall.* When the entire yearling production system was evaluated, SUPP steers (\$16.45/animal) tended (P = 0.09) to be more profitable than CON steers (\$6.10/animal) if sold on a live animal basis (Table 10). Moreover, SUPP steers were \$19.15/animal more (P = 0.02) profitable in a value-based marketing system when compared to CON steers. These data suggest the value of premiums awarded when steers were sold on a grid were more than the value of additional weight. Clearly, less expensive summer gains achieved through strategic supplementation offer producers' options when growing and marketing yearling cattle. There was no effect (P > 0.35) of feedlot sorting treatment on overall profitability of cattle sold live or on a grid. In this production scenario, value of additional weight sold was not great enough to offset increased production costs from extra time on feed required to finish lighter BW animals.

*Price Comparison.* The price comparison between the 5-yr average and the 26 July 2011 price point illustrates a 125% increase in corn (SB, MDGS) price and an

average 23% increase in cattle prices, which is reflective of current market volatility. Because all animals were managed as a single group during winter backgrounding, no effect of summer grazing or feedlot sorting treatments was observed when 26 July 2011 prices were used in economic calculations (Table 11). Consistent with 5-yr prices, feed costs, yardage, transportation costs, and market/risk management fees were greater (P < 0.01) for SUPP than CON steers during summer grazing (Table 12). However, increases in feed costs were greater than increases in prices paid for feeder cattle, causing SUPP steers to be \$11.81/animal less (P = 0.03) profitable than CON steers after summer. This illustrates the sensitivity of production systems to inputs costs and ownership decisions. In agreement with this, Jenkins et al. (2009) found an optimal DDGS supplementation level was dependent on marketing strategy and DDGS cost.

With higher prices, SUPP steers cost \$84.70/animal more (P < 0.01) at feedlot entry compared to CON steers (Table 13). Expensive feed and additional days on feed drove total costs up for CON steers, such that total costs were \$29.97/animal less (P < 0.01) for SUPP steers than CON contemporaries. Despite increased fed cattle prices, there was no effect (P = 0.92) of summer grazing treatment on live steer value. Thus, SUPP steers were \$29.12/animal more (P < 0.01) profitable than CON steers during finishing. Increased commodity prices also caused finishing BE to favor (P < 0.01) SUPP over CON steers. In agreement with 5-yr prices, overall profitability favored summer supplementation. Profit of the entire production system was \$18.49/animal greater (P < 0.01) for SUPP steers when sold live (Table 13). Even with increased commodity and cattle prices, BW gain achieved from summer supplementation reduced

enough of the feed costs required during finishing to be profitable. These data illustrate if ownership of yearling cattle is maintained until harvest, gain achieved during summer grazing from supplementation will decrease feedlot inputs and improve overall profitability.

### **IMPLICATIONS**

Steers fed 0.6% BW MDGS on the ground had increased ADG and BW at the end of summer grazing, and were more profitable. Supplemented steers were fed 24 fewer days, had greater LM area, and lower marbling when harvested at a similar final BW and 12<sup>th</sup> rib fat thickness as non-supplemented steers. Steers sorted on feedlot entry BW had increased HCW, marbling, and YG; but percentage overweight carcasses and profitability were similar with non-sorted steers. Subsequent savings in the feedlot from BW gain attained during summer supplementation are great enough such that the overall production system is cost-effective, even in volatile markets.

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Table 1. Nutrient analysis of modified distillers grains with solubles<sup>1</sup>

Nutrient	DM, %
СР	29.0
Ether extract	11.8
NDF	42.5
Sulfur	0.53

<sup>&</sup>lt;sup>-1</sup>45.8% DM

Table 2. Premiums and discounts/45.4 kg used to determine final grid value

determine final grid value	
Item	Price
HCW	
182 - 227  kg	-24.52
228 - 249  kg	-15.60
250 - 272  kg	-3.04
273 - 408  kg	0.00
409 – 431 kg	-1.46
432 - 453  kg	-4.59
> 453 kg	-19.33
YG	
1	2.87
2	1.25
3	-0.06
4	-13.15
5	-19.04
QG	
Prime	9.30
Upper 2/3 choice	2.91
Lower 1/3 choice	0.00
Select	-8.59
Standard	-17.51

Table 3. Winter and summer performance of yearling steers supplemented MDGS on grass and sorted on feedlot entry BW

	<u> </u>	• 0	1.1		0		•	<i>y</i>	
	COl	$N^1$	SUI	$PP^2$			P-value <sup>3</sup>		
Item	NOSORT <sup>4</sup>	SORT <sup>5</sup>	NOSORT	SORT	SE	Summer	Feedlot	SxF	
Winter									
Initial BW, kg	227	226	226	226	3	0.71	0.79	0.52	
Ending BW, kg	316	317	316	317	3	0.92	0.14	0.71	
ADG, kg	0.64	0.64	0.64	0.65	0.03	0.74	0.14	0.68	
Summer <sup>6</sup>									
Ending BW, kg	415	416	464	463	5	< 0.01	0.90	0.61	
ADG, kg	0.62	0.62	0.92	0.91	0.03	< 0.01	0.55	0.56	

<sup>&</sup>lt;sup>1</sup>CON = grazed native summer range with no supplement.

<sup>&</sup>lt;sup>2</sup>SUPP = grazed native summer range with modified wet distillers grains with solubles supplemented 0.6% BW.

 $<sup>^{3}</sup>P$ -Value: Summer = effect of summer grazing treatment; Feedlot = effect of feedlot sorting treatment; S x F = effect of treatment interaction.

<sup>&</sup>lt;sup>4</sup>SORT = sorted on feedlot entry BW.

<sup>&</sup>lt;sup>5</sup>NO SORT = not sorted.

<sup>&</sup>lt;sup>6</sup>Summer = 23 d brome grass + 136 d native summer range; Initial BW = Ending BW from winter.

Table 4. Feedlot performance and carcass characteristics of yearling steers supplemented MDGS on grass and sorted on

feedlot entry BW

	CO	$N^1$	SUI	$PP^2$			<i>P</i> -value <sup>3</sup>	
Item	NOSORT <sup>4</sup>	SORT <sup>5</sup>	NOSORT	SORT	SE	Summer	Feedlot	SxF
Days on feed	126	133	102	111	1	< 0.01	< 0.01	< 0.01
DMI, kg	13.8	13.6	13.8	13.4	0.2	0.16	0.02	0.24
ADG, kg	1.82	1.81	1.80	1.72	0.12	0.07	0.17	0.29
G:F, kg/kg	0.132	0.132	0.130	0.129	0.007	0.22	0.81	0.60
HCW, kg	406	413	407	411	6	0.92	0.01	0.41
LM area, cm <sup>2</sup>	88.08	87.76	90.52	89.70	1.62	0.01	0.46	0.74
12 <sup>th</sup> rib fat thickness, cm	1.25	1.32	1.25	1.28	0.16	0.57	0.21	0.57
Marbling score <sup>6</sup>	596	630	559	556	13	< 0.01	0.05	0.02
Calculated YG <sup>7</sup>	3.26	3.40	2.96	3.15	0.16	< 0.01	0.02	0.76

<sup>&</sup>lt;sup>1</sup>CON = grazed native summer range with no supplement.

<sup>&</sup>lt;sup>2</sup>SUPP = grazed native summer range with modified wet distillers grains with solubles supplemented 0.6% BW.

 $<sup>^{3}</sup>P$ -Value: Summer = effect of summer grazing treatment; Feedlot = effect of feedlot sorting treatment; S x F = effect of treatment interaction.

<sup>&</sup>lt;sup>4</sup>SORT = sorted on feedlot entry BW.

<sup>&</sup>lt;sup>5</sup>NO SORT = not sorted.

<sup>&</sup>lt;sup>6</sup>Marbling: Small<sup>00</sup> = 500, Small<sup>50</sup> = 550, Modest<sup>00</sup> = 600.

<sup>&</sup>lt;sup>7</sup>Calculated YG = (2.5 + (5.51 x 12 th rib fat thickness) - (0.70 x LM area) + (0.2 x KPH) + (0.0084 x HCW).

Table 5. Rate of change per day for carcass characteristics

of serially harvested long yearling steers

	0	
Item	$CON^1$	$SUPP^2$
HCW, kg	0.8910	0.9415
LM area, cm <sup>2</sup>	0.1323	0.1422
12 <sup>th</sup> rib fat thickness, cm	-0.0019	0.0043
Marbling score <sup>3</sup>	1.8583	3.0646
Calculated YG <sup>4</sup>	-0.0010	0.0224

 $<sup>{}^{1}</sup>CON =$ grazed native summer range with no supplement.

<sup>&</sup>lt;sup>2</sup>SUPP = grazed native summer range with modified wet distillers grains with solubles supplemented at 0.6% BW. <sup>3</sup>Marbling: Small<sup>00</sup> = 500, Small<sup>50</sup> = 550, Modest<sup>00</sup> = 600.

 $<sup>^{4}</sup>$ Calculated yield grade = (2.5 + (5.51 x 12th rib fat thickness)

 $<sup>-(0.70 \</sup>text{ x LM area}) + (0.2 \text{ x KPH}) + (0.0084 \text{ x HCW})$ .

Table 6. Carcass weight, quality grade, and yield grade frequencies of yearling steers supplemented MDGS on grass and sorted on feedlot entry BW

-	COl	$CON^{1}$		$PP^2$		P-value <sup>3</sup>		
Item	NOSORT <sup>4</sup>	SORT <sup>5</sup>	NOSORT	SORT	SE	Summer	Feedlot	SxF
HCW								
272 – 408 kg, %	49.7	43.5	54.1	44.4	20.3	0.90	0.70	0.93
409 – 431 kg, %	32.5	31.1	27.4	37.1	19.7	0.99	0.83	0.91
432 – 453 kg, %	12.9	20.9	10.7	15.1	16.6	0.80	0.68	0.94
> 453 kg, %	5.0	4.5	7.8	3.4	8.9	0.96	0.80	0.84
Quality grade								
Prime, %	14.0	25.9	4.5	6.7	17.9	0.35	0.69	0.91
Upper 2/3 choice, %	32.5	31.1	72.6	70.9	19.3	0.90	0.83	0.78
Lower 1/3 choice, %	13.4	7.9	22.3	22.4	17.0	0.45	0.81	0.80
Yield grade								
1, %	1.1	2.3	10.8	5.1	12.6	0.55	0.99	0.77
2, %	31.2	26.1	40.7	34.5	20.1	0.59	0.83	0.94
3, %	57.7	54.8	41.2	44.4	20.3	0.52	0.99	0.88
4, %	8.9	16.3	6.2	12.1	13.3	0.80	0.61	0.99
5, %	1.1	0.6	1.2	0.6	4.4	0.99	0.88	0.99

<sup>&</sup>lt;sup>1</sup>CON = grazed native summer range with no supplement.

<sup>2</sup>SUPP = grazed native summer range with modified wet distillers grains with solubles supplemented at 0.6% BW.

 $<sup>^{3}</sup>P$ -Value: Summer = effect of summer grazing treatment; Feedlot = effect of feedlot sorting treatment; S x F = effect of treatment interaction.

<sup>&</sup>lt;sup>4</sup>SORT = sorted on feedlot entry BW.

<sup>&</sup>lt;sup>5</sup>NO SORT = not sorted.

Table 7. Winter economics of yearling steers<sup>1</sup> supplemented MDGS on grass and sorted on feedlot entry BW using 2006-2010 mean prices

	CO	$CON^2$		SUPP <sup>3</sup>		P-value <sup>4</sup>		
Item	NOSORT <sup>5</sup>	SORT <sup>6</sup>	NOSORT	SORT	SE	Summer	Feedlot	SxF
Steer cost, \$/animal	525.98	523.52	523.24	524.27	6.98	0.71	0.79	0.52
Feed, \$/ animal	68.22	68.22	68.22	68.22	0.93			
Variable cost, \$/ animal	53.91	53.89	53.87	53.90	0.87	0.74	0.97	0.53
Total cost, \$/ animal	669.35	666.87	666.57	667.63	9.35	0.71	0.79	0.52
Steer value, \$/ animal	769.28	771.60	768.31	772.19	5.99	0.92	0.14	0.70
Profit/loss, \$/ animal	99.93	104.74	101.74	104.56	7.50	0.75	0.14	0.70
Cost of gain, \$/45.4 kg	73.60	71.48	72.41	71.51	2.92	0.73	0.17	0.70
Breakeven, \$/45.4 kg	96.14	95.50	95.87	95.55	1.18	0.75	0.18	0.65

<sup>&</sup>lt;sup>1</sup>CON – NOSORT steers adjusted to breakeven (profit = \$0.00/animal) for entire system.

<sup>&</sup>lt;sup>2</sup>CON = grazed native summer range with no supplement.

<sup>&</sup>lt;sup>3</sup>SUPP = grazed native summer range with modified wet distillers grains with solubles supplemented at 0.6% BW.

 $<sup>^4</sup>P$ -Value: Summer = effect of summer grazing treatment; Feedlot = effect of feedlot sorting treatment; S x F = effect of treatment interaction.

<sup>&</sup>lt;sup>5</sup>SORT = sorted on feedlot entry BW.

<sup>&</sup>lt;sup>6</sup>NO SORT = not sorted.

Table 8. Summer economics of yearling steers<sup>1</sup> supplemented MDGS on grass and sorted on feedlot entry BW using 2006-2010 mean prices

	CO	$\frac{\text{CON}^2}{5}$ $\frac{\text{SUPP}^3}{5}$				P-value <sup>4</sup>		
Item	NOSORT <sup>5</sup>	SORT <sup>6</sup>	NOSORT	SORT	SE	Summer	Feedlot	SxF
Steer cost \$/ animal	769.28	771.60	768.31	772.19	5.99	0.92	0.14	0.70
Rent, \$/ animal	79.31	79.31	65.84	65.84	1.60	< 0.01		
MDGS, \$/ animal	0.00	0.00	44.77	44.77	0.57	< 0.01		
Feed, \$/ animal	79.31	79.31	110.61	110.61	2.10	< 0.01		
Yardage, \$/ animal	16.03	16.03	32.07	32.07	0.54	< 0.01		
Variable cost, \$/ animal	36.94	36.97	53.66	53.69	0.50	< 0.01	0.82	0.99
Total cost, \$/ animal	932.69	935.04	981.33	985.23	5.77	< 0.01	0.16	0.72
Steer value, \$/ animal	953.88	955.96	1013.89	1012.69	11.95	< 0.01	0.90	0.62
Profit/loss, \$/ animal	21.18	20.92	32.57	27.45	8.23	0.03	0.50	0.54
Cost of gain, \$/45.4 kg	75.39	75.41	65.32	66.37	2.68	< 0.01	0.64	0.66
Breakeven, \$/45.4 kg	102.08	102.11	96.07	96.58	0.84	< 0.01	0.52	0.57

<sup>&</sup>lt;sup>1</sup>CON – NOSORT steers adjusted to breakeven (profit = \$0.00/animal) for entire system.

<sup>&</sup>lt;sup>2</sup>CON = grazed native summer range with no supplement.

<sup>&</sup>lt;sup>3</sup>SUPP = grazed native summer range with modified wet distillers grains with solubles supplemented at 0.6% BW.

 $<sup>^{4}</sup>$ *P*-Value: Summer = effect of summer grazing treatment; Feedlot = effect of feedlot sorting treatment; S x F = effect of treatment interaction.

<sup>&</sup>lt;sup>5</sup>SORT = sorted on feedlot entry BW.

<sup>&</sup>lt;sup>6</sup>NO SORT = not sorted.

Table 9. Feedlot economics of yearling steers<sup>1</sup> supplemented MDGS on grass and sorted on feedlot entry BW using 2006-2010 mean prices

	CO	$N^2$	SU	SUPP <sup>3</sup>		<i>P</i> -value <sup>4</sup>		
Item	NOSORT <sup>5</sup>	SORT <sup>6</sup>	NOSORT	SORT	SE	Summer	Feedlot	SxF
Steer cost \$/ animal	953.88	955.96	1013.89	1012.69	11.95	< 0.01	0.90	0.62
Feed, \$/ animal	256.03	266.35	208.96	217.30	3.85	< 0.01	< 0.01	0.60
Yardage, \$/ animal	56.72	59.89	45.80	49.78	0.22	< 0.01	< 0.01	< 0.01
Variable cost, \$/ animal	80.31	83.67	70.01	74.08	0.22	< 0.01	< 0.01	< 0.01
Total cost, \$/ animal	1363.95	1380.23	1364.87	1376.57	8.94	0.69	< 0.01	0.51
Live value, \$/ animal	1242.83	1266.58	1247.48	1260.56	18.36	0.91	0.01	0.41
Grid value, \$/ animal	1253.46	1265.45	1259.90	1270.33	10.97	0.34	0.07	0.89
Live profit, \$/ animal	-121.12	-113.65	-117.39	-116.01	26.57	0.92	0.52	0.66
Grid profit, \$/ animal	-110.49	-114.78	-104.97	-106.24	18.62	0.34	0.70	0.84
Cost of gain, \$/45.4 kg	81.94	81.19	87.83	87.82	5.44	< 0.01	0.76	0.77
Live breakeven, \$/45.5 kg	96.21	95.59	95.90	95.74	2.00	0.88	0.46	0.66
Grid breakeven, \$/45.4 kg	152.72	151.73	152.23	151.97	3.18	0.88	0.45	0.66

<sup>&</sup>lt;sup>1</sup>CON – NOSORT steers adjusted to breakeven (profit = \$0.00/animal) for entire system.

<sup>&</sup>lt;sup>2</sup>CON = grazed native summer range with no supplement.

<sup>&</sup>lt;sup>3</sup>SUPP = grazed native summer range with modified wet distillers grains with solubles supplemented at 0.6% BW.

 $<sup>{}^4</sup>P$ -Value: Summer = effect of summer grazing treatment; Feedlot = effect of feedlot sorting treatment; S x F = effect of treatment interaction.

<sup>&</sup>lt;sup>5</sup>SORT = sorted on feedlot entry BW.

<sup>&</sup>lt;sup>6</sup>NO SORT = not sorted.

Table 10. Overall profit or loss of yearling steers<sup>1</sup> supplemented MDGS on grass and sorted on feedlot entry BW using 2006-2010 mean prices

	CO	$CON^2$		SUPP <sup>3</sup>		P-value <sup>4</sup>		
Item	NOSORT <sup>5</sup>	SORT <sup>6</sup>	NOSORT	SORT	SE	Summer	Feedlot	SxF
Live profit, \$/ animal	0.00	12.20	16.91	15.99	19.17	0.09	0.35	0.28
Grid profit, \$/ animal	10.63	10.87	29.33	25.76	13.53	0.02	0.81	0.78

<sup>&</sup>lt;sup>1</sup>CON – NOSORT steers adjusted to breakeven (profit = \$0.00/animal) for entire system.

<sup>&</sup>lt;sup>2</sup>CON = grazed native summer range with no supplement.

<sup>&</sup>lt;sup>3</sup>SUPP = grazed native summer range with modified wet distillers grains with solubles supplemented at 0.6% BW.

 $<sup>^4</sup>P$ -Value: Summer = effect of summer grazing treatment; Feedlot = effect of feedlot sorting treatment; S x F = effect of treatment interaction.

<sup>&</sup>lt;sup>5</sup>SORT = sorted on feedlot entry BW.

<sup>&</sup>lt;sup>6</sup>NO SORT = not sorted.

Table 11. Winter economics of yearling steers supplemented MDGS on grass and sorted by BW into the feedlot based on 24 July 2011 prices

	CO	$N^1$	SUPP <sup>2</sup>			P-value <sup>3</sup>			
Item	NOSORT <sup>4</sup>	SORT <sup>5</sup>	NOSORT	SORT	SE	Summer	Feedlot	SxF	
Steer cost, \$/ animal	739.22	735.77	735.38	736.83	9.81	0.71	0.79	0.52	
Feed, \$/ animal	128.20	128.20	128.20	128.20	1.74				
Variable cost, \$/ animal	57.11	57.07	57.06	57.09	0.91	0.75	0.96	0.54	
Total cost, \$/ animal	947.62	944.13	943.72	945.20	13.54	0.71	0.79	0.52	
Steer value, \$/ animal	939.85	942.69	938.66	943.40	7.32	0.92	0.14	0.70	
Profit/loss, \$/ animal	-7.77	-1.45	-5.07	-1.81	10.87	0.73	0.18	0.66	
Cost of gain, \$/45.4 kg	106.20	103.90	105.27	103.96	4.36	0.74	0.17	0.70	
Breakeven, \$/45.4 kg	136.11	135.20	135.72	135.27	1.57	0.74	0.18	0.65	

<sup>&</sup>lt;sup>1</sup>CON = grazed native summer range no supplement.

<sup>&</sup>lt;sup>2</sup>SUPP = grazed native summer range with modified wet distillers grains with solubles supplemented at 0.6% BW.

 $<sup>^{3}</sup>P$ -Value: Summer = effect of summer grazing treatment; Feedlot = effect of feedlot sorting treatment; S x F = effect of treatment interaction.

<sup>&</sup>lt;sup>4</sup>SORT = sorted on feedlot entry BW. <sup>5</sup>NO SORT = not sorted.

Table 12. Summer economics of yearling steers supplemented MDGS on grass and sorted by BW into the feedlot based on 24 July 2011 prices

	CC	$DN^1$	SU	SUPP <sup>2</sup>			P-value <sup>3</sup>	
Item	NOSORT <sup>4</sup>	SORT <sup>5</sup>	NOSORT	SORT	SE	Summer	Feedlot	SxF
Steer cost \$/ animal	939.85	942.69	938.66	943.40	7.32	0.92	0.14	0.70
Rent, \$/ animal	79.31	79.31	65.84	65.84	1.60	< 0.01		
MDGS, \$/ animal	0.00	0.00	90.39	90.39	1.15	< 0.01		
Feed, \$/ animal	79.31	79.31	156.23	156.23	2.64	< 0.01		
Yardage, \$/ animal	16.03	16.03	32.07	32.07	0.54	< 0.01		
Variable cost, \$/ animal	37.79	37.82	54.51	54.41	0.50	< 0.01	0.81	0.98
Total cost, \$/ animal	1104.14	1107.01	1199.70	1204.47	7.04	< 0.01	0.17	0.73
Steer value, \$/ animal	1181.38	1183.96	1268.13	1266.62	14.84	< 0.01	0.90	0.62
Profit/loss, \$/ animal	77.24	76.95	68.43	62.15	10.24	0.03	0.51	0.54
Cost of gain, \$/45.4 kg	75.79	75.82	80.05	81.34	2.87	< 0.01	0.58	0.59
Breakeven, \$/45.4 kg	120.85	120.89	117.46	118.07	0.99	< 0.01	0.50	0.57

<sup>&</sup>lt;sup>1</sup>CON = grazed native summer range no supplement.

<sup>&</sup>lt;sup>2</sup>SUPP = grazed native summer range with modified wet distillers grains with solubles supplemented at 0.6% BW.

 $<sup>{}^{3}</sup>P$ -Value: Summer = effect of summer grazing treatment; Feedlot = effect of feedlot sorting treatment; S x F = effect of treatment interaction.

<sup>&</sup>lt;sup>4</sup>SORT = sorted on feedlot entry BW.

<sup>&</sup>lt;sup>5</sup>NO SORT = not sorted.

Table 13. Feedlot economics and overall profit or loss of yearling steers supplemented MDGS on grass and sorted by BW into the feedlot based on 24 July 2011 prices

	CON <sup>1</sup>		$SUPP^2$			<i>P</i> -value <sup>3</sup>		
Item	NOSORT <sup>4</sup>	SORT <sup>5</sup>	NOSORT	SORT	SE	Summer	Feedlot	SxF
Feedlot								
Steer cost \$/ animal	1181.38	1183.96	1268.13	1266.62	14.84	< 0.01	0.90	0.62
Feed, \$/ animal	542.04	563.88	442.38	460.04	8.20	< 0.01	< 0.01	0.60
Yardage, \$/ animal	56.72	59.89	45.80	49.78	0.22	< 0.01	< 0.01	< 0.01
Variable cost, \$/ animal	80.87	84.24	70.64	74.71	0.21	< 0.01	< 0.01	< 0.01
Total cost, \$/ animal	1881.79	1910.47	1855.65	1876.68	9.29	< 0.01	< 0.01	0.46
Live value, \$/ animal	1537.29	1566.66	1543.04	1559.22	22.71	0.92	0.01	0.41
Live profit, \$/ animal	-344.50	-343.81	-312.61	-317.46	30.65	< 0.01	0.81	0.74
Cost of gain, \$/45.4 kg	139.92	138.98	146.98	147.18	8.96	< 0.01	0.86	0.79
Live breakeven, \$/45.5 kg	132.73	132.31	130.38	130.52	2.51	< 0.01	0.83	0.67
Overall								
Live profit, \$/animal	-275.03	-268.30	-249.24	-257.12	22.28	0.02	0.94	0.33

<sup>&</sup>lt;sup>1</sup>CON = grazed native summer range with no supplement.

<sup>&</sup>lt;sup>2</sup>SUPP = grazed native summer range with modified wet distillers grains with solubles supplemented at 0.6% BW.

 $<sup>{}^{3}</sup>P$ -Value: Summer = effect of summer grazing treatment; Feedlot = effect of feedlot sorting treatment; S x F = effect of treatment interaction.

<sup>&</sup>lt;sup>4</sup>SORT = sorted on feedlot entry BW.

<sup>&</sup>lt;sup>5</sup>NO SORT = cattle not sorted.

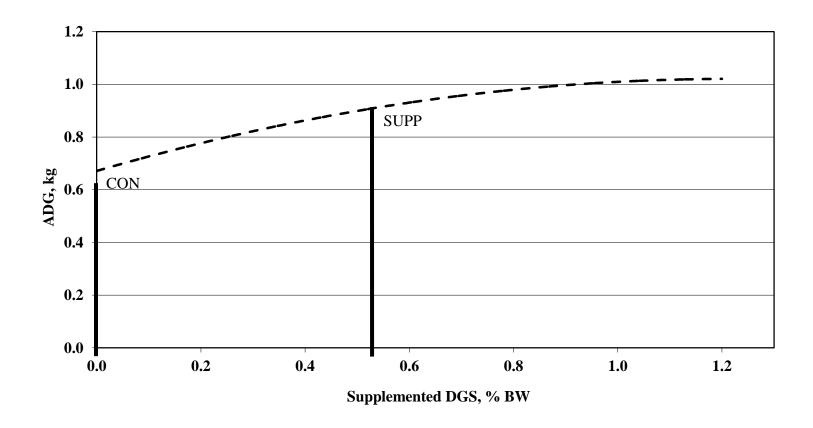


Figure 1. Effect of supplementing modified wet distillers grains with solubles during summer grazing on ADG, superimposed on ADG response to dried distillers grains supplementation observed in Griffin et al. (2011)

## **CHAPTER III**

# Influence of weaning date and late gestation supplementation on cow-calf productivity<sup>1</sup>

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<sup>1</sup>This work is a contribution of the University of Nebraska Agricultural Research

Division, supported in part by funds provided through the Hatch Act.

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### **ABSTRACT**

A 3-yr trial was conducted to elucidate long-term effects of weaning date and prepartum supplementation on cow-calf productivity in a spring calving system. Each year, 144 crossbred beef cows (BW =  $492 \pm 46$  kg) were used in a completely randomized design with a 2x4 factorial arrangement of treatments: 1) cows were weaned in early October or early December; and 2) during the last trimester of pregnancy, cows were fed 0.00, 0.45, 0.91 kg DM/cow daily of a 32% CP supplement on dormant upland range; or grazed corn residue without supplement. October weaned cows grazing winter range had greater (P < 0.01) BCS and BW compared to December weaned cows pre-calving. Dams fed supplement on range or wintered on corn residue had greater (P < 0.01) BCS and BW prior to parturition and breeding. But, subsequent pregnancy rates (88.9% - 97.2%) were not influenced (P > 0.28) by weaning or winter management. Adjusted weaning BW was lowest (P = 0.04) for December we aned calves born to dams wintered on range without supplement. There were no differences (P > 0.13) in percentage heifers cycling before breeding (33%) or pregnancy rate (79%). Steer progeny born to dams receiving supplement or wintered on corn residue had greater (P = 0.03) 12<sup>th</sup> rib fat thickness at harvest. Weaning date had no effect (P > 0.19) on net change in return of pre-weaning cow and calf production or of steer progeny during finishing. Retaining ownership of steers born to supplemented dams through harvest may result in the greater net change in return, because BW advantage is more likely to be realized at this point.

**Key words**: beef cattle, maternal nutrition, weaning, supplementation

## **INTRODUCTION**

Harvested forages are one of the greatest costs accrued during winter for a spring calving system. Dormant forage, however, does not meet the high nutrient demands of the pregnant cow in the last trimester of pregnancy (NRC, 1996). Research has determined that only 0.14 kg DM/cow daily of supplemental RDP is necessary to maintain BCS of gestating cows grazing winter range (Hollingsworth-Jenkins et al., 1996). Supplementation of 0.45 kg DM/cow daily (42% CP) has been shown to increase BCS and percentage of live calves at weaning compared to cows not receiving supplemental protein, but may have minimal impact on pregnancy rate if cows are in adequate condition prior to calving (Stalker et al., 2006). Adjusting weaning date of a spring calving system may also help maintain cow BCS on winter range (Stalker et al., 2007). However, in that study, researchers were unable to detect a difference in pregnancy rates, possibly because cows were not weaned late enough in the year.

Undernutrition causes suboptimal conditions in the maternal uterine environment which translates into depressed progeny performance (Wu et al, 2006). Unfortunately, the exact mechanisms causing these deleterious responses are complex and not well understood (Funston et al., 2010a), especially from a production system perspective. Therefore, the objectives of the current study were to evaluate long-term effects of prepartum protein supplement and weaning date and the interactions on: cow reproduction; heifer progeny growth and reproduction; and steer progeny growth, feedlot performance, and carcass characteristics. The hypothesis being that an interaction between weaning date and winter grazing management will be present; such that

December weaned dams wintered on range without supplement will have poorer BCS and subsequent reproductive performance, and produce poorer performing progeny.

### MATERIALS AND METHODS

All procedures and facilities were utilized under the approval of the University of Nebraska-Lincoln Institutional of Animal Care and Use Committee. A 3-yr experiment used 144 crossbred, March calving cows (initial BW =  $492 \pm 46$  kg) to elucidate longterm effects of weaning date and pre-partum supplementation on cow-calf productivity at the Gudmundsen Sandhills Laboratory (Whitman, NE). Cows were stratified by age and treatments were assigned randomly in a 2 x 4 factorial arrangement: 1) cows were weaned in early October (OCT) or early December (DEC); and 2) December 1 to February 28, cows were fed the equivalent of 0.0, 0.45, 0.91 kg DM/cow daily of a supplement (Table 1) on dormant winter range (WR0, WR1, WR2, respectively); or grazed corn residue without supplement (CR). Winter treatments were applied on a pasture basis, and both October and December weaned dams were maintained in a single pasture. Pasture or corn residue forage was not limiting at any time. Therefore, each group of weaned cows within pasture served as the experimental unit. Each treatment combination applied to the cows was replicated 3 times within year. Cows remained on the same weaning and winter grazing treatments for the duration of the experiment. This trial is not yet completed, and details of data available for analyses will be described herein. For this discussion, a production year will begin post-weaning (October 2) and last until the subsequent weaning (October 1).

# Cow-calf Management

Cows were managed as a single herd the entire trial, except when winter grazing treatments were applied (December 1 to February 28). After December weaning, dams were relocated to dormant upland range pastures, or transported to corn residue fields. Supplement was delivered 3 times/wk on a pasture (35.6 ha) basis. Prior to calving, cows were moved to dormant sub-irrigated meadows and vaccinated against Clostridium perfringens C, Escherichia coli, Rotavirus, Coronavirus (Scour Guard 4KC; Pfizer Animal Health, New York, NY). At birth, calves were vaccinated against Clostridium chauvoei, Clostridium septicum, Clostridium novyi, Clostridium sordellii, and Clostridium perfringens C and D. (Alpha-7; Boehringer Ingelheim Vetmedica, St. Joseph, MO). At calving, cows were fed *ad libitum* hay. Calving rate was calculated by dividing the number of cows to calve by the number of pregnant cows (all open cows removed and replaced each year). All calves were branded and all bull calves were castrated via surgical removal the last week of April and dosed with Once PMH SQ (Intervet Schering Plough, DeSoto, KS) to prevent bovine respiratory disease caused by *Pasteurella* haemolytica and Pasteurella multocida.

Prior to breeding, cows were relocated to upland range pastures and vaccinated with Vista 3 VL5 SQ (Intervet Schering Plough, DeSoto, KS) to prevent major viral (Infectious bovine rinotracheitis virus, Bovine viral diarrhea virus, Leptospira canicola, L. grippotyphosa, L. hardjo, L. icterohaemorrhagiae, and L. pomona) diseases of the respiratory system. Cows were estrus synchronized and artificially inseminated with semen from the same 2 bulls each year. Prior to weaning date and winter grazing treatment assignment the first year, CIDRs (Pfizer Animal Health, New York, NY) were

inserted, cows were administered a dose of PG (Prostamate, Agri Laboratories, St. Joseph, MO) on d-6, and CIDRs (Pfizer Animal Health, New York, NY) were removed on d-7. Heat was detected and cows were artificially inseminated for 4 d. The remaining years, estrus was synchronized with 2 injections of PG (Prostamate, Agri Laboratories, St. Joseph, MO) 2 wk apart, followed by heat detection and artificial insemination for 6 d. Cows were then placed with bulls (1:20 bull:cow) for 45 d. The same clean-up bulls were used each year. Pregnancy was determined via rectal palpation or ultrasonography by a veterinarian at October weaning. Pregnancy rate was calculated by dividing the number of cows determined pregnant by the original number of cows in the treatment.

Prior to and at weaning, calves were re-vaccinated against viral infection (Infectious bovine rhinotracheitis virus, Bovine virus diarrhea virus, Parainfluenza-3 virus, Bovine respiratory syncytial virus, Mannheimia haemolytica, and Pasteurella multocida) with Express 5-PHM (Boehringer Ingelheim Vetmedica, St. Josheph, MO) and bacterial infection (Clostridium chauvoei, Clostridium septicum, Clostridium novyi, Clostridium sordellii, and Clostridium perfringens C and D) with Ultrabac 7/Somubac (Pfizer Animal Health, New York, NY). At the time of October weaning, weaned calves were relocated to cool season meadows and supplemented to gain the equivalent of non-weaned contemporaries until the December weaning, or 0.45 kg DM/calf daily of a supplement (Table 1). The basis of the supplement amount fed to weaned calves was established in the same upland range pastures using calves grazing meadow re-growth (Lamb et al., 1996). Weaning rate was calculated by dividing the number of cows to wean a calf by the original number of cows in the treatment. Percentage calves weaned

was calculated by dividing the number of cows to wean a calf by the number of cows to calve. Adjusted 205 d BW of progeny was calculated by regressing BW on days of age. After December weaning, October and December weaned calves were fed *ad libitum* hay in a dry-lot for approximately 14 d as a single group.

Cow and calf data reported herein were collected in 2009 (n = 144), 2010 (n = 144), and 2011 (n = 144; from weaning until subsequent breeding). Cow BCS and cow and calf BW were measured at October weaning, December weaning, pre-calving, and pre-breeding. Body condition score was measured via manual palpation of individual animals using a 1 to 9 scale (Herd and Sprott, 1986). Body weights were taken after at least 12 hours without feed and water. Cows were removed from the study if they were not pregnant or if calf death or a phenotypic discrepancy occurred (Table 2). Cow death was assumed to be related to treatment unless struck by lightning (n = 2) or missing (n = 1). Phenotypic discrepancies (n = 7), such as lump jaw, bulling and c-section, were assumed to be unrelated to treatment. Three-yr old replacement females were stratified by BW and allotted randomly to treatment of removed cows. Influences of dam treatments on progeny performance were of interest; therefore, no further treatments were imposed and calves were followed post-weaning.

# Heifer Management

After December weaning, October and December weaned heifers were relocated to sub-irrigated meadows, fed 0.45 kg DM/heifer daily of supplement (Table 1), and managed as a single group for the remainder of the study. Prior to breeding, heifers were given 2 doses of Vista 3 VL5 SQ (Intervet Schering Plough, DeSoto, KS) 14 d apart to

prevent viral infection (Infectious bovine rinotracheitis virus, Bovine viral diarrhea virus, Leptospira canicola, L. grippotyphosa, L. hardjo, L. icterohaemorrhagiae, and L. pomona). At the time of breeding, heifers were moved to upland range pastures to graze for the remainder of the yr. Blood samples were collected twice, 10 d apart prior to placement with bulls. After collection, samples were immediately placed on ice. Concentrations of serum progesterone were determined by direct solid phase RIA (Coat-A-Count, Diagnostics Products Corp., Los Angeles, CA). Heifers were considered cycling (ovarian luteal activity present) if blood serum progesterone concentrations were > 1.0 ng/mL. Estrus was synchronized with a single injection of PG (Prostamate, Agri Laboratories, St. Joseph, MO) administered 108 h after bulls were introduced to heifers. An adequate bull-to-heifer ratio (1:20) was maintained throughout the breeding season (45 d) and the same clean-up bulls were utilized each yr. Pregnancy was determined via rectal palpation or ultrasonography on about August 30. Heifer data reported herein were collected in 2010 (n = 69) and 2011 (n = 68) from December weaning until pregnancy determination. Heifer BW was measured pre-breeding and BW and BCS were measured at pregnancy determination. All heifers were retained as replacements (Table 3).

# Steer Management

After the dry-lot period, steers were transported to the feedlot at West Central Research and Extension Center (North Platte, NE); where they were limit fed 5 d at 2.0% BW, weighed 2 consecutive days in an effort to reduce variation in BW (Stock et al., 1983), and implanted with Synovex S (200 mg progesterone and 20 mg estradiol benzoate; Pfizer Animal Health, New York, NY). Steers were placed into 1 of 8 pens

based on dam weaning and winter grazing treatment. Pen size was variable across treatments (4 to 12 steers in 2009; 6 to 10 steers in 2010); however, feed bunk space ( $\geq$ 50.8 cm/steer) and pen space were adequate and did not limit steer performance. Steers were adapted (21 d) to a common finishing diet of 48% dry rolled corn, 40% corn gluten feed, 7% prairie hay, and 5% supplement. Approximately 100 d prior to harvest, steers were re-implanted with Revalor S (120 mg trenbolone acetate and 8 mg estradiol; Intervet Schering Plough, DeSoto, KS) and administered with an ectoparasiticide (Decamax; Pfizer Animal Health, New York, NY). Because steers were pen fed, DMI and G:F were adjusted within pen for average BW of individual animal. Harvest date was targeted for 1.27 cm 12<sup>th</sup> rib fat thickness. A commercial abattoir was used for harvest (Tyson, Lexington, NE in 2009; National Beef, Dodge City, KS in 2010), and carcass data were collected by trained personnel after a 24-h chill. Final BW was calculated from HCW and an assumed dressing percentage (63%). Steer data reported were collected in 2010 (n = 64) and 2011 (n = 68) from December weaning until harvest. One OCT weaned steer born to a WR1 dam died in the feedlot in 2011 due to chronic respiratory problems.

# Economic Analyses

A partial budget was created to illustrate economic implications of weaning in October or December, as well as different winter grazing management options. Net change in return (**NCR**) was calculated by subtracting additional costs from additional income (Baquet, 2000). Analyses were based on mean prices from 2006 to 2010.

Cow-calf. Range cost was valued at \$25.51/AUM (Johnson et al., 2010) for May 1 through October 31, and \$12.26/AUM for November 1 through April 30. Pasture rental rates reported in Johnson et al. (2010) assumed 1 AUM was equal to 590 kg. Range costs were based off BW of cow and/or calf in an effort to account for any treatment differences observed. From December 1 to February 28, range cost for cows on WR treatments were calculated by multiplying the regional pasture rental rate by the average BW of the cow. A \$0.05/cow per day charge for fence maintenance and animal management was included for all WR cows. Supplement fed to WR1 and WR2 cows was charged at \$280.32/908 kg DM, or \$0.14/0.45 kg DM; which was the actual price paid. An additional \$0.05/cow per day was charged to WR1 and WR2 cows to account for the cost of supplement delivery (equipment, fuel, labor, etc.). Cows wintered on CR were charged \$0.50/cow daily, which was the actual price paid during the experiment. This cost included fence maintenance and animal management; therefore, additional daily charges were not necessary. Transportation for CR cows was charged at \$4.00/loaded 1.61 km to and from corn residue fields (157 km). Therefore, total transportation costs were calculated by multiplying rate by total distance and average BW, assuming a semitruck could haul 22,700 kg. For the remainder of the year (March 1 to September 30), monthly range cost was calculated by multiplying the regional pasture rental rate by the average BW of the cow and calf combined. Because cows were managed as a single group from March 1 to September 30, other changes in return were assumed to be equal across weaning and winter grazing treatments.

Commercial cow slaughter and national pregnant cow prices were based on 2006 to 2010 mean (Cattle Fax, Centennial, CO). Cull cows were valued by multiplying cow weaning BW by commercial cow harvest price in October (\$47.18/45.4 kg) or December (\$44.83/45.4 kg), respectively. Replacement pregnant cows were priced at \$965.47 and \$995.04/cow in October and December, respectively. Cull cow income and replacement cow cost was adjusted for replacement rate of cows, which was calculated by dividing the number of cows replaced by the original number of cows in the treatment. Thus, any treatments that had greater replacement rates also had greater income from cull cows and greater replacement cow cost.

October feeder steers and heifers were \$124.00 and \$113.25/45.4 kg (USDA, 2011f), respectively; and December feeder steers and heifers were \$121.71 and \$112.68/45.4 kg (USDA, 2011f), respectively. A \$5.10/45.4 kg price slide was used to adjust feeder calf price for differences in BW within dam treatment combination (Dhuyvetter et al., 2001). It was assumed that on average weaned calf crop was 50% heifers and 50% steers. Weaned calf crop was also adjusted for any calf deaths that occurred from birth to weaning. Two separate partial budgets were calculated to evaluate the effects of maternal treatments on this cow-calf production system from birth to weaning and from birth to December. The purpose of doing this was to compare the cost of selling OCT weaned calves at weaning or backgrounding OCT weaned calves for 2 mo, or until DEC weaning. October weaned cows were charged for supplemental feed offered to weaned calves at the same price as described earlier, for 60 d.

Steers. Changes in net return during the finishing phase were determined on steer progeny, assuming retained ownership until harvest. The finishing diet for all steers was 48% dry rolled corn, 40% corn gluten feed, 7% prairie hay, and 5% dry supplement. Therefore, corn was charged at \$3.76/25.4 kg DM (USDA, 2011b), corn gluten feed was charged at \$127.42/908 kg DM (95% corn price; USDA, 2011b), prarie hay was charged at \$87.04/908 kg DM (USDA, 2010a), and supplement was charged at \$200.00/908 kg DM. Fed cattle were priced live, as well as on a grid (Table 4; USDA, 2011, c,d,e), or \$141.62/45.4 kg of HCW. Live fed cattle sales price was \$140.86/45.4 kg of HCW (USDA, 2011e). The transportation cost was calculated as described above with the actual mean distance to the feedlot (225 km) and to the harvest facility (285 km).

#### Statistical Analyses

Weaning date within pasture served as the experimental unit. Replicated treatment means within yr were used for analyses of cow, calf, heifer, and steer response variables. Model fixed effects included weaning date, winter grazing treatment, and the interaction. Year and residual error were considered random effects. Data were analyzed with the GLIMMIX procedure of SAS (SAS Inst., Inc., Cary, NC). Effects of treatment or the interaction were considered significant when P < 0.05 as detected by Fischer's test. When the F-test was significant, least square means of treatments were separated using a t-test when P < 0.05. Due to several interactions between effect of weaning date and winter grazing treatments, data are reported as simple effects. Where an interaction is not present, main effects are discussed.

#### RESULTS AND DISCUSSION

# Cow- calf

Body condition of cows was not different (P > 0.12) among weaning or winter grazing treatments in October (Table 5). Dams weaned in October maintained BCS until December; whereas cows still nursing calves lost BCS during that time. Thus, BCS of OCT dams was 0.3 units greater (P < 0.01) than DEC dams in December. Interestingly, OCT dams maintained condition from December to pre-calving; and, BCS of DEC dams increased slightly. The interaction between weaning and winter grazing treatments was significant (P = 0.04) for pre-calving and pre-breeding BCS. However, the data followed a similar pattern for BCS within weaning treatment, where WR0 cows had the lowest BCS and BCS increased as level of nutrition in late gestation increased.

Effect of weaning on BW mirrored that of BCS, where BW of OCT and DEC dams was similar (P = 0.15) in October; and OCT dams were 30 kg heavier (P < 0.01) than DEC dams in December. This response carried through winter, and OCT dams were still 24 kg heavier (P < 0.01) than DEC dams prior to calving. In October, CR dams were 15 kg heavier (P = 0.04) than WR0 and WR2 dams, with WR1 cows being intermediate; but there was no effect (P = 0.10) of winter grazing management in December. After winter grazing treatments were applied (pre-calving), CR dams were the heaviest (P < 0.01); WR2 dams were intermediate, followed by WR0 and WR1, which were not different. An interaction was observed (P < 0.01) between weaning and winter grazing treatments prior to breeding for BW. Within weaning date, CR dams were the heaviest. However, within October weaning, WR1 cows were 13 kg heavier than WR2 cows.

BW and BCS prior to calving, subsequent pregnancy rates were not affected (P > 0.28) by weaning or winter grazing treatments and averaged 93%. Numerically, WR0 and WR1 dams had the lowest and highest pregnancy rates of 89.3% and 95.2%, respectively.

Similar effects of weaning on BCS and BW were found by Stalker et al. (2007) on dams weaned 1 mo earlier. Likewise, Short et al. (1996) weaned cows 90 d apart and observed at the time of the late wean, nursing cows weighed 32 kg less and had over 1.0 unit less BCS compared to dams weaned earlier. December weaned cows also had less BW and BCS pre-calving, which is also in agreement with these data. In the current experiment, CR cows were 71 kg heavier prior to calving that WR0 cows; and Larson et al. (2009) found cows grazing corn residue during late gestation were 42 kg heavier prior to calving than cows wintered on range. In contrast, Anderson et al. (2005) found cows fed hay had greater BW and BCS than cows grazing corn residue, but authors attributed this to greater quality and quantity of forage in the hay compared to the corn residue.

Research indicates time of weaning may have minimal impact on subsequent pregnancy rates or calving interval (Basarab et al., 1986; Short et al., 1996; Story et al., 2000; Stalker et al., 2007). Pregnancy rates were similar between dams' supplemented pre-partum and those not supplemented in a spring calving system (Stalker et al., 2006, 2007). In agreement with this, Larson et al. (2009) observed similar pregnancy rates between cows wintered on range or corn residue that were supplemented or not supplemented 90 d prior to parturition. Subsequent pregnancy rates may be unaffected by late gestation supplementation or early weaning, as was seen in the current experiment. This is likely because non-supplemented and late weaned cows are managed

to maintain a moderate BCS, or basal diets provided (native range or hay) are of high enough quality such that reproduction appears unchanged. Freetly et al. (2000) demonstrated this when cows calving at a moderate BCS received treatments changing body reserves during the third trimester showed no differences in subsequent pregnancy rate. Post-partum nutrition of cows may also have been sufficient enough to counteract any differences seen after winter grazing.

Cows weaned in December calved 3 d earlier (P = 0.01) than OCT dams, but calving date was similar (P = 0.16) across winter grazing treatments. Similarly, calving rate was greater (P = 0.02) for OCT than DEC dams, but not different (P = 0.28) among winter grazing treatments. Birth BW of progeny born to WR0 cows was 2 kg less (P < 0.01) than all remaining winter grazing treatments (Table 6). Likewise, October and December BW were lightest (P < 0.01) for progeny born to WR0 dams, with progeny BW increasing parallel to dam nutritional plane during late gestation. Birth BW was not different (P = 0.15) between weaning treatments; but OCT cows had calves that were 7 and 21 kg heavier (P < 0.01) in October and December, respectively, than DEC cows. This indicates the amount of supplement provided to the October weaned progeny was greater than necessary, since the goal was to achieve similar BW in December from both weaning treatments. The interaction between weaning and winter grazing treatments was significant (P = 0.04) for adjusted 205 d BW of calves. In general, calves born to dams with higher global nutrition were heavier. There was a tendency (P = 0.09) for weaning rate to favor OCT dams over DEC dams, by 4.8%. This is in contrast to Stalker et al. (2007) who observed no difference in percentage live calves weaned when March calving cows were weaned in August or November. Winter grazing management did not affect (P > 0.65) weaning rate or percentage calves weaned. These data do not agree with Corah et al. (1975), who fed young cows energy deficient diets in late gestation and found decreased percentage live calves at weaning. Differences in diet quality and lack of passive immunity transfer have been attributed as potential causes for decreased percentage live calves weaned for cows fed supplement (Stalker et al., 2006).

# Heifers

October weaned heifers were 18 kg greater (P < 0.01) in December than DEC heifers (Table 7). Pre-breeding and pregnancy determination BW of OCT heifers were at least 14 kg greater (P < 0.01) than DEC contemporaries. However, BCS of OCT and DEC heifers was similar (P = 0.38) at pregnancy determination, averaging 5.6. Average daily gain (0.42 kg) of heifers from December weaning to subsequent breeding was similar (P > 0.11) between weaning treatments. No differences (P > 0.13) in percentage cycling before breeding or pregnancy rates were found. Percentage of heifers cycling was low and ranged from 39.6 to 55.9% for OCT and DEC heifers, respectively. Numerically, DEC heifers had an 8.6% greater pregnancy rate than OCT heifers. December weaned heifers had 0.04 kg greater (P = 0.03) ADG than OCT heifers during summer on native Sandhills range. In contrast, Story et al. (2000) found early weaned heifers had decreased BW at the remaining weaning dates, but BW was similar across treatments at breeding. The difference in response to weaning in Story et al. (2000) compared to the current experiment is likely due to post-weaning management of early weaned calves. Because OCT calves were supplemented 0.45 kg DM/calf daily for 60 d,

BW in December was greater than DEC calves. Compensatory gain of DEC heifers was observed during summer grazing, but was not great enough to cause BW at pregnancy diagnosis to be similar. Sexten et al. (2005) weaned heifers at 89 or 232 d and found early weaning increased percentage of heifers pubertal by 8 mo. Numerically, data from the current experiment agree with this, as 13.1% more OCT than DEC heifers were cycling prior to breeding.

December and pre-breeding BW were greater (P < 0.01) for heifers born to CR dams than heifers born to dams on any other winter grazing treatment. At the time of pregnancy determination, the response to winter grazing treatment lessened, and only a tendency (P = 0.07) for heifers born to dams on a higher nutritional plane to have greater BW was observed. Winter grazing management had no effect (P > 0.53) on postweaning or summer ADG. Heifers born to dams on CR tended (P > 0.09) to have the greatest BCS at pregnancy determination compared to heifers born to dams on all other winter grazing treatments. However, percentage cycling (33.0%) and pregnancy rates (79.3%) were not different (P > 0.29). Funston et al. (2010b) found heifers born to dams supplemented or non-supplemented and wintered on range or corn residue to have similar ADG from weaning to breeding; but, heifers born to supplemented dams tended to reach puberty sooner. In contrast, Martin et al. (2007) found no effect of dam nutrition on percentage of heifers exhibiting ovarian luteal activity prior to breeding or pubertal age. In agreement with this, Corah et al. (1975) observed no difference in age at puberty of heifers born to dams severely restricted during the last 100 d of gestation compared to non-restricted dams. Based on the wide range of restriction applied to dams during late

gestation in Corah et al. (1975) and Martin et al. (2007), it is doubtful that pubertal age of heifer progeny is predictably affected.

#### Steers

Feedlot initial BW of OCT steers was 17 kg greater (P < 0.01) than DEC steers (Table 8). Steer progeny had similar (P > 0.37) DMI, ADG, and G:F in the feedlot regardless of weaning treatment. Interestingly, HCW was similar (P = 0.29) between weaning treatments, which was not expected because OCT steers were heavier at feedlot entry and were on feed for the same number of days as DEC steers. These data indicate DEC steers may have experienced compensatory gain, but lack of power could have prevented these differences from being detected statistically. Numerically, DEC steers had 0.2 kg/d, 0.03 kg, and 0.001 kg/kg greater DMI, ADG, and G:F compared to OCT steers. Moreover, the difference in weight between OCT and DEC steers decreased from 17 to 7 kg from feedlot entry to harvest, respectively. Weaning date did not affect (P >0.28) LM area, 12<sup>th</sup> rib fat thickness, marbling score, or yield grade. Myers et al. (1999) observed improved feedlot ADG when steer calves were weaned at 90 and 152 d compared to 215 d. Similarly, Fluharty et al. (2000) found a 5% improvement in G:F when steers were weaned 100 d earlier than contemporaries. However, other data found early weaned steers entered the feedlot 38 kg lighter and consumed 0.5 kg/d less than late weaned steers (Stalker et al., 2007). The primary difference between the feedlot performance data in these experiments is the feedlot entry BW. Animals entering the feedlot at a heavier BW, regardless of weaning treatments, are expected to consume more DM and be less efficient than lighter animals when harvested at a similar endpoint.

Effect of weaning on carcass characteristics are in agreement with Myers et al. (1999), Story et al. (2000) and Stalker et al. (2007), who found no differences among early and late weaning treatments for HCW, LM area, YG, marbling score or QG.

Steers born to dams on a higher nutritional plane were heavier at feedlot entry (P = 0.02), with steers born to WR1, WR2, and CR dams having 12, 18, and 24 kg greater initial BW than steers born to WR0 cows, respectively. Dry matter intake and G:F were also similar across winter grazing treatments. However, there was a tendency (P = 0.10)for steers born to WR2 and CR dams to have greater feedlot ADG than steers born to WR0 and WR1 dams. Steers born to WR1, WR2, and CR dams had 13, 23, and 30 kg greater (P = 0.02) HCW than steers born to WR0 cows, respectively. Winter grazing treatment did not affect (P > 0.14) LM area, marbling score, or yield grade. Twelfth rib fat thickness was greatest (P = 0.03) for steers born to CR dams, and lowest for steers born to WR0 dams, with steers born to WR1 and WR2 cows being intermediate. Stalker et al. (2006) found no differences in any carcass characteristics between steers born to dams with and without pre-partum supplementation. In agreement with these data, Larson et al. (2009) reported steers born to protein supplemented dams on winter range to have 8 kg greater HCW than non-supplemented cows. In contrast, however, marbling score and percent grading USDA Choice or greater were also greater for steers born to protein supplemented dams compared to non-supplemented dams. Summers et al. (2011) also observed greater marbling scores in steer progeny born to supplemented dams, compared to non-supplemented dams. Fetal programming effects of late gestation nutrition on progeny growth and composition are likely. Across domestic livestock

species, intrauterine growth restriction caused from inadequate maternal nutrition decreases feed efficiency, increases whole-body and intramuscular fat and decreases meat quality of progeny (Wu et al., 2006).

## **Economics**

Cow-calf. Supplement cost for WR1 and WR2 cows during winter grazing was \$12.60 and \$25.20/cow (Table 9), respectively. Yardage to account for animal/facility management and/or supplement delivery for WR0 cows was \$4.50/cow, and \$9.00/cow for WR1 and WR2 cows. Pasture rent within the system was \$223.26/cow when calves were sold at weaning. Transportation to and from corn residue was \$17.42/cow for CR dams. Replacement cow cost was \$139.63/cow across wean and winter grazing treatments. Numerically, replacement cow cost \$10.87/cow greater for DEC than OCT dams. Within winter grazing management, WR0 and WR2 cows had the greatest and least replacement cow cost, at \$204.10 and \$95.20/cow, respectively. Total cost (\$382.33/cow) was similar (P > 0.68) across weaning and winter grazing treatments. Patterns of total cost mirror that of replacement cow cost with DEC dams having \$18.19/cow greater cost than OCT dams. Similarly, the greatest and least total cost was observed for WR0 and WR2 cows, at \$421.60 and \$348.93/cow, respectively. Income from cull cows was \$68.23/cow and followed similar patterns as replacement cow cost because both values are based on replacement female rates. When all calves were sold at weaning, the calf crop was valued at \$546.40/cow. Interestingly, OCT dams had \$9.81/cow numerically greater weaned calf income than DEC dams. In contrast, Stalker et al. (2007) found marketing lighter BW; early weaned calves may result in fewer net

returns even though market prices are usually elevated at that time. The primary differences between these data are likely calf BW at weaning and feeder calf price. Early weaned calves in Stalker et al. (2007) were lighter BW than late weaned calves at weaning; whereas, OCT calves in the current experiment were 7 kg heavier than DEC calves at weaning. October feeder calf price was also \$2.29 and 0.57/45.4 kg greater than the December feeder price of steers and heifers, respectively; because calves were lighter in October.

Total income, however, was not different (P = 0.46) between OCT (\$621.07/cow) and DEC dams (\$607.67/cow). Likewise, there was no effect (P = 0.74) of winter grazing management on total income. Therefore, NCR (\$232.30/cow) was similar (P > 0.34) across weaning and winter grazing treatments. However, weaning in December reduced NCR by \$32.12/cow compared to October weaning. Within October weaning, CR dams had the greatest increase in NCR relative to WR0 dams, due to 7 kg greater calf BW at weaning, as well as greater weaning rate. Stalker et al. (2006) reported similar results. But within December weaning, WR2 cows had the greatest increase in NCR relative to WR0 dams, followed by CR and WR1 dams. In this case, calf BW was similar at weaning between WR2 and CR dams. Because CR dams had greater pasture cost from corn residue rental, transportation cost, higher replacement rate, and lower percentage calves weaned, WR2 dams had greater NCR, comparatively. Similarly, increased costs associated with supplement and delivery were greater than the value of additional weight sold, resulting in decreased net returns at weaning in Larson et al. (2009).

A \$4.20 and \$3.00/cow supplement and yardage cost was calculated for OCT dams, if weaned calves were backgrounded for 60 d (Table 10). Additionally, pasture rent was \$14.40/cow greater for OCT dams when weaned calves were sold in December, due to calf grazing cost. Therefore, backgrounding weaned calves increased total cost of OCT dams \$21.60/cow, but was not different (P = 0.94) from DEC dams at that time. Backgrounding OCT calves for 2 mo also increased weaned calf income \$41.26/cow. When sold in December, additional BW gain of calves caused total income of OCT dams to be greater (P < 0.01) than DEC dams, but NCR was not different (P = 0.19). Still, backgrounding OCT calves from October to December increased NCR \$19.37/cow.

Steers. Feed and transportation cost for steers during finishing was \$345.46 and \$24.07/cow (Table 11). An interaction (P < 0.01) for total cost was observed between weaning and winter grazing treatments. This was likely caused by relative differences in DMI among treatments. Within October weaning, WR0 and WR2 steers had the lowest DMI, which was reflected in lower feed and total cost. However, within December weaning, WR1 steers had the lowest DMI, feed, and total cost. Live value of steers at harvest was affected (P = 0.02) by dam winter grazing management. Steers born to WR0 dams had the lowest live value (\$1093.82/cow), and this increased as maternal nutrition increased, with steers born to CR cows having the greatest live value (\$1182.92/cow). Increased weight sold of steers born to dams on higher nutritional plane caused this difference, and was reflected in HCW. There was a tendency (P = 0.08) for grid value of steers to show the same pattern within winter grazing management, but weaning treatments were similar (P = 0.42). Percentage carcasses grading Low Choice or greater

was 98% across all treatments, leaving little room for improvement in quality grade to be detected in a grid formula. Twelfth rib fat thickness impacted yield grade premiums and discount of the grid, but most of the winter grazing treatment effect seen in grid value was likely due to HCW. Therefore, NCR when steers were sold live was greater (P =0.03) for steers born to dams on a higher nutritional plane. In contrast, Funston et al. (2010b) found wintering cows on corn residue increased the value of weaned steers and net returns at weaning, but not in finishing. Negligible differences in net returns through finishing have also been reported when dams were supplemented late gestation or not (Stalker et al. 2006). Conversely, Larson et al. (2009) attributed increased percentage Choice carcasses and HCW to a \$30.00/animal advantage in net feedlot return of steers born to dams receiving protein supplement, compared to steers from non-supplemented dams. Data from the current experiment agree with Stalker et al. (2007), and suggest retaining ownership of steers born to protein supplemented dams through harvest will result in the greatest increase in NCR, because BW advantage is more likely to be realized at this point.

Live and grid value of steers at harvest was similar (P > 0.29) between OCT and DEC steers. There was no effect (P > 0.24) of weaning treatment on NCR, regardless of steer marketing. In agreement with this, Story et al. (2000) found no effect of time of weaning on net income per animal, when steers were harvested a constant  $12^{th}$  rib fat thickness. In the current experiment, December weaning reduced NCR by \$23.58 and \$19.09/cow when steer progeny were sold live and on a grid, respectively. However, this is a function of over-supplementing OCT calves when backgrounded from weaning to

December. October weaned calves were 7 kg heavier than DEC calves in October and 21 kg heavier than DEC calves in December. Any subsequent weaning treatment results or conclusions calculated as function of BW are confounded with over-supplementation post-weaning.

## **IMPLICATIONS**

An interaction between weaning date and winter grazing management was not consistently present in these data. March calving dams receiving supplement on range or wintered on corn residue will have greater BCS and BW prior to parturition and breeding. However, subsequent pregnancy rates for cows may be similar among weaning and winter grazing management if dams are maintained in adequate condition. Pre-weaning and weaning BW of calves born to dams receiving supplement on range or wintered on corn residue will be greater. Subsequent effect of weaning date and dam maternal nutrition may have minimal impact on heifer progeny percentage cycling prior to breeding or pregnancy rate. Steer progeny born to receiving supplement on range or wintered on corn residue may have greater 12<sup>th</sup> rib fat thickness at harvest. Retaining ownership of steers born to protein supplemented dams through harvest may result in the greater net change in return, because BW advantage is more likely to be realized at this point.

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**Table 1.** Composition and nutrient analysis of supplement<sup>1</sup>

Item	DM, %
Ingredient	
Dried distillers grains with solubles	62.0
Wheat middlings	11.0
Cottonseed meal	9.0
Dried corn gluten feed	5.0
Molasses	5.0
Calcium carbonate	3.0
Trace minerals and vitamins <sup>1</sup>	3.0
Urea	2.0
Nutrient	
CP	31.6
Undegradable intake protein, % CP	47.6
TDN	89.4

If formulated inclusion of 80 mg/cow daily of monensin.

**Table 2.** Number of cows<sup>1</sup> removed from the study<sup>2</sup>

		Oct	ober				Dece	mber	
Item	WR0	WR1	WR2	CR	_	WR0	WR1	WR2	CR
Year 1									
Open	3	0	1	1		2	2	1	1
Died	0	0	1	0		1	0	1	0
Calf died	0	0	0	0		1	2	1	2
Culled <sup>3</sup>	1	1	0	0		0	0	0	0
Year 2									
Open	1	1	0	2		1	0	0	1
Died	$1^4$	1	$1^4$	0		1	0	0	$1^4$
Calf died	1	0	0	0		0	2	0	0
Culled <sup>3</sup>	1	1	1	1		1	0	0	0
Year 3 <sup>5</sup>									
Died	0	0	0	0		0	0	0	0
Calf died	0	0	0	1		1	1	0	1

<sup>&</sup>lt;sup>1</sup>Weaned in October or December; WR0: winter range without supplement;

WR1: winter range with 0.45 kg DM/cow daily 32% CP supplement; WR2: winter range with 0.91 kg DM/cow daily 32% CP supplement; CR: corn residue without supplement.

<sup>&</sup>lt;sup>2</sup>Each treatment had 18 cows at the beginning of each year; cows removed from the study were replaced to maintain treatment numbers.

<sup>&</sup>lt;sup>3</sup>Culled due to lump jaw, bulling, bad eye, prolapse, and c-section; assumed not related to weaning or winter grazing treatment.

<sup>&</sup>lt;sup>4</sup>Cow struck by lightning or missing; assumed not related to weaning or winter grazing treatment

<sup>&</sup>lt;sup>5</sup>Only data from weaning until subsequent breeding available for analysis.

**Table 3.** Number of heifer progeny<sup>1</sup> removed from the study

		Oct	ober			December						
Item	WR0	WR1	WR2	CR	•	WR0	WR1	WR2	CR			
Year 1												
Open	4	3	1	3		5	0	2	1			
Died	0	1	1	0		0	0	1	0			
Year 2												
Open	2	2	2	3		2	1	0	1			
Died	0	0	0	0		0	0	0	0			

After December weaning; dams weaned in October or December; WR0: winter range without supplement; WR1: winter range with 0.45 kg DM/cow daily 32% CP supplement; WR2: winter range with 0.91 kg DM/cow daily 32% CP supplement; CR: corn residue without supplement.

**Table 4.** Premiums and discounts/45.4 kg used to determine final grid value

kg used to determine i	final grid value
Item	Price
HCW	
182 - 227  kg	-25.16
228 - 249  kg	-9.27
250 - 272  kg	-2.38
273 - 408  kg	0.00
409 - 431  kg	-1.58
432 - 453  kg	-4.48
> 453 kg	-19.33
YG	
1	2.93
2	1.23
3	-0.05
4	-12.98
5	-19.19
HCW	
Prime	9.53
Choice	1.64
Select	-9.59
Standard	-20.40

**Table 5.** Effects of weaning date<sup>1</sup> and winter grazing treatment<sup>2</sup> on cow BCS, BW, calving date, calving rate, pregnancy rate, weaning rate, and percentage live calves weaned

		Oc	tober			Dece	ember			P-value <sup>3</sup>		
Item	WR0	WR1	WR2	CR	WR0	WR1	WR2	CR	SE	Wean	Winter	WxW
BCS												
October	5.1	5.3	5.1	5.2	5.3	5.2	5.1	5.3	0.2	0.21	0.12	0.19
December	5.1	5.3	5.2	5.3	4.9	4.8	4.9	4.8	0.1	< 0.01	0.97	0.19
Pre-calve	4.7 <sup>d</sup>	5.1°	5.3 <sup>abc</sup>	5.5 <sup>a</sup>	$4.6^{\mathrm{d}}$	4.7 <sup>d</sup>	5.2 <sup>bc</sup>	5.4 <sup>ab</sup>	0.1	< 0.01	< 0.01	0.04
Pre-breed	4.9 <sup>c</sup>	$5.2^{a}$	5.1 <sup>a</sup>	$5.2^{a}$	4.9 <sup>bc</sup>	4.9 <sup>c</sup>	5.1 <sup>ab</sup>	$5.2^{\mathrm{a}}$	0.1	0.08	< 0.01	0.04
BW												
October, kg	489	502	484	504	489	478	486	501	9	0.15	0.04	0.14
December, kg	476	485	466	486	450	437	447	458	11	< 0.01	0.10	0.13
Pre-calve, kg	479	501	522	553	461	459	511	529	7	< 0.01	< 0.01	0.14
Pre-breed, kg	455 <sup>def</sup>	483 <sup>bc</sup>	$470^{\rm cd}$	500 <sup>a</sup>	453 <sup>ef</sup>	443 <sup>f</sup>	467 <sup>de</sup>	$488^{ab}$	12	< 0.01	< 0.01	< 0.01
Calving date, d	83	81	83	82	85	83	83	87	4	0.01	0.16	0.23
Calving rate <sup>4</sup> , %	100.0	100.0	100.0	98.1	94.4	92.6	100.0	98.1	2.0	0.02	0.28	0.14
Pregnancy rate <sup>5</sup> , %	88.9	97.2	91.7	91.7	89.7	93.1	97.2	94.4	4.4	0.96	0.28	0.86
Weaning rate <sup>6</sup> , %	97.2	97.2	97.2	100.0	91.7	88.9	97.2	94.4	4.0	0.09	0.65	0.76
Calves weaned <sup>7</sup> , %	94.4	97.2	94.4	100.0	96.7	96.7	97.2	91.7	3.1	0.66	0.97	0.26

<sup>&</sup>lt;sup>1</sup>Dams weaned in October or December.

<sup>&</sup>lt;sup>2</sup>WR0: winter range without supplement; WR1: winter range with 0.45 kg DM/cow daily 32% CP supplement; WR2: winter range with 0.91 kg DM/cow daily 32% CP supplement; CR: corn residue without supplement.

<sup>&</sup>lt;sup>3</sup>Wean: weaning date main effect; Winter: winter grazing treatment main effect; WxW: weaning date by winter grazing treatment interaction; superscripts shown only if interaction present.

<sup>&</sup>lt;sup>4</sup>Calving rate calculated by dividing the number of cows to calve by the number of pregnant cows; open cows removed from the study each year and replaced.

<sup>&</sup>lt;sup>5</sup>Pregnancy rate calculated by dividing the number of cows determined pregnant by the original number of cows in the treatment.

<sup>&</sup>lt;sup>6</sup>Weaning rate calculated by dividing the number of cows to wean a calf by the original number of cows in the treatment.

<sup>&</sup>lt;sup>7</sup>Calves weaned calculated by dividing the number of cows to wean a calf by the number of cows to calve.

**Table 6.** Effects of weaning date<sup>1</sup> and winter grazing treatment<sup>2</sup> of dams on calf BW and BW gain

		Oct	ober			December					<i>P</i> -value <sup>3</sup>			
Item	WR0	WR1	WR2	CR	WR0	WR1	WR2	CR	SE	Wean	Winter	WxW		
BW														
Birth, kg	35	36	36	35	33	35	36	36	1	0.15	< 0.01	0.13		
October, kg	201	220	217	225	192	206	218	219	4	< 0.01	< 0.01	0.18		
December, kg	228	247	242	251	206	217	230	230	4	< 0.01	< 0.01	0.13		
Adj. wean <sup>4</sup> , kg	179 <sup>bc</sup>	195 <sup>a</sup>	193 <sup>a</sup>	198 <sup>a</sup>	179 <sup>c</sup>	181 <sup>b</sup>	196 <sup>a</sup>	198 <sup>a</sup>	3	0.03	< 0.01	0.04		

<sup>&</sup>lt;sup>1</sup>Dams weaned in October or December.

<sup>&</sup>lt;sup>2</sup>WR0: winter range without supplement; WR1: winter range with 0.45 kg DM/cow daily 32% CP supplement; WR2: winter range with 0.91 kg DM/cow daily 32% CP supplement; CR: corn residue without supplement.

<sup>&</sup>lt;sup>3</sup>Wean: weaning date main effect; Winter: winter grazing treatment main effect; WxW: weaning date by winter grazing treatment interaction; superscripts shown only if interaction present.

<sup>&</sup>lt;sup>4</sup>Weaning BW adjusted to 205 days of age.

**Table 7.** Effects of weaning date<sup>1</sup> and winter grazing treatment<sup>2</sup> of dams on first calf heifer progeny BW, ADG, BCS, percentage cycling prior to breeding, and pregnancy rate

		Oct	ober			Dece	ember			P-value <sup>3</sup>		
Item	WR0	WR1	WR2	CR	WR0	WR1	WR2	CR	SE	Wean	Winter	WxW
BW												
December, kg	209	220	231	231	194	209	206	211	10	< 0.01	< 0.01	0.63
Pre-breed, kg	280	292	297	303	261	280	276	275	11	< 0.01	< 0.01	0.55
Pregnancy, kg	327	335	343	349	314	329	326	329	11	< 0.01	0.07	0.82
ADG												
Post-wean <sup>4</sup> , kg	0.42	0.44	0.41	0.45	0.39	0.43	0.42	0.38	0.04	0.11	0.75	0.37
Summer <sup>5</sup> , kg	0.38	0.35	0.36	0.36	0.41	0.38	0.39	0.43	0.04	0.03	0.53	0.85
BCS												
Pregnancy	5.8	5.6	5.6	5.7	5.4	5.6	5.5	5.7	0.1	0.38	0.09	0.58
Cycling <sup>6</sup> , %	28.7	36.1	55.0	38.4	30.9	32.8	28.7	13.4	13.2	0.13	0.59	0.54
Pregnancy rate <sup>7</sup> , %	73.9	76.1	86.1	63.9	67.5	91.7	88.9	86.1	9.6	0.22	0.29	0.46

<sup>&</sup>lt;sup>1</sup>Dams weaned in October or December.

<sup>&</sup>lt;sup>2</sup>WR0: winter range without supplement; WR1: winter range with 0.45 kg DM/cow daily 32% CP supplement; WR2: winter range with 0.91 kg DM/cow daily 32% CP supplement; CR: corn residue without supplement.

<sup>&</sup>lt;sup>3</sup>Wean: weaning date main effect; Winter: winter grazing treatment main effect; WxW: weaning date by winter grazing treatment interaction; superscripts shown only if interaction present.

<sup>&</sup>lt;sup>4</sup>Calculated from December weaning date to subsequent average breeding date (161 d).

<sup>&</sup>lt;sup>5</sup>Calculated from average breeding date to subsequent October weaning date (139 d).

<sup>&</sup>lt;sup>6</sup>Considered cycling if blood serum progesterone concentrations taken prior to breeding were > 1.0 ng/mL.

<sup>&</sup>lt;sup>7</sup>Pregnancy rate calculated by dividing the number of heifers determined pregnant by the number of heifers in the treatment.

**Table 8.** Effects of weaning date<sup>1</sup> and winter grazing treatment<sup>2</sup> of dams on steer progeny growth, feedlot performance, and carcass characteristics

		Oct	ober			Dece	ember			P-value <sup>3</sup>		
Item	WR0	WR1	WR2	CR	WR0	WR1	WR2	CR	SE	Wean	Winter	WxW
Initial BW, kg	229	254	244	257	219	218	239	239	8	< 0.01	0.02	0.23
DMI <sup>4</sup> , kg/d	10.3	10.6	10.4	11.0	10.7	10.3	11.0	10.9	0.6	0.43	0.29	0.41
ADG, kg	1.57	1.58	1.60	1.64	1.55	1.59	1.69	1.69	0.09	0.37	0.10	0.70
$G:F^4$	0.156	0.152	0.156	0.151	0.148	0.157	0.156	0.157	0.003	0.75	0.50	0.10
HCW, kg	333	351	347	361	324	329	355	356	16	0.29	0.02	0.46
LM area, cm <sup>2</sup>	80.98	83.01	83.91	86.11	80.60	81.08	85.95	83.58	3.61	0.64	0.14	0.68
FT <sup>5</sup> , cm	1.74	1.97	1.74	1.91	1.52	1.72	1.82	1.98	0.17	0.28	0.03	0.23
Marbling <sup>6</sup>	497	533	505	512	481	514	512	533	20	0.93	0.23	0.65
YG	2.81	2.91	2.64	2.81	2.35	2.64	2.72	2.96	0.32	0.31	0.35	0.27

<sup>&</sup>lt;sup>1</sup>Dams weaned in October or December.

<sup>&</sup>lt;sup>2</sup>WR0: winter range without supplement; WR1: winter range with 0.45 kg DM/cow daily 32% CP supplement; WR2: winter range with 0.91 kg DM/cow daily 32% CP supplement; CR: corn residue without supplement.

<sup>&</sup>lt;sup>3</sup>Wean: weaning date main effect; Winter: winter grazing treatment main effect; WxW: weaning date by winter grazing treatment interaction; superscripts shown only if interaction present.

<sup>&</sup>lt;sup>4</sup>Adjusted for BW.

<sup>7</sup>12<sup>th</sup> rib fat thickness.

<sup>6</sup>Marbling: Small<sup>00</sup> = 400, Small<sup>50</sup> = 450, Modest<sup>00</sup> = 500.

**Table 9.** Effects of weaning date and winter grazing treatment on dams and progeny until weaning on net change in return (\$\/cow)

		Oct	ober			Dece	ember			<i>P</i> -value <sup>3</sup>			
Item	WR0	WR1	WR2	CR	WR0	WR1	WR2	CR	SE	Wean	Winter	WxW	
Cow supplement	0.00	12.60	25.20	0.00	0.00	12.60	25.20	0.00					
Calf supplement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					
Cow yardage	4.50	9.00	9.00	0.00	4.50	9.00	9.00	0.00					
Calf yardage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					
Pasture	208.62	218.37	213.33	237.70	217.39	216.20	225.73	248.76					
Transportation	0.00	0.00	0.00	17.82	0.00	0.00	0.00	17.02					
Replacement cows	214.66	107.33	107.49	107.33	193.54	165.34	82.92	138.48					
Total cost	427.77	347.30	355.02	362.85	415.43	403.15	342.85	404.26	59.74	0.70	0.68	0.91	
Cull cows	114.52	58.06	56.70	52.62	89.93	72.34	37.19	64.51					
Weaned calves	508.63	553.48	553.70	588.67	505.95	526.54	575.29	558.91					
Total income	623.15	611.54	610.39	641.29	595.88	598.87	612.48	623.43	26.49	0.46	0.74	0.96	
NCR <sup>4</sup>	195.38	264.25	255.38	278.44	180.46	195.73	269.63	219.16	47.40	0.34	0.43	0.80	
Difference <sup>5</sup>		68.87	60.00	83.07		15.27	89.17	38.71					

<sup>&</sup>lt;sup>1</sup>Dams weaned in October or December.

<sup>&</sup>lt;sup>2</sup>WR0: winter range without supplement; WR1: winter range with 0.45 kg DM/cow daily 32% CP supplement; WR2: winter range with 0.91 kg DM/cow daily 32% CP supplement; CR: corn residue without supplement.

<sup>&</sup>lt;sup>3</sup>Wean: weaning date main effect; Winter: winter grazing treatment main effect; WxW: weaning date by winter grazing treatment interaction; superscripts shown only if interaction present.

<sup>&</sup>lt;sup>4</sup>Net change in return calculated by subtracting feed, transportation, and replacement female value from cull female value and value of calves at weaning or December.

<sup>&</sup>lt;sup>5</sup>Difference in net change in return relative to dams wintered on range without supplement.

**Table 10.** Effects of weaning date<sup>1</sup> and winter grazing treatment<sup>2</sup> on dams and progeny until December on net change in return (\$/cow)

		Oct	ober			Dece	ember				<i>P</i> -value <sup>3</sup>	
Item	WR0	WR1	WR2	CR	WR0	WR1	WR2	CR	SE	Wean	Winter	WxW
Cow supplement	0.00	12.60	25.20	0.00	0.00	12.60	25.20	0.00				
Calf supplement	4.20	4.20	4.20	4.20	0.00	0.00	0.00	0.00				
Cow yardage	4.50	9.00	9.00	0.00	4.50	9.00	9.00	0.00				
Calf yardage	3.00	3.00	3.00	3.00	0.00	0.00	0.00	0.00				
Pasture	221.94	233.30	227.67	252.70	217.39	216.20	225.73	248.76				
Transportation	0.00	0.00	0.00	17.82	0.00	0.00	0.00	17.02				
Replacement cows	214.66	107.33	107.49	107.33	193.54	165.34	82.92	138.48				
Total cost	448.29	369.43	376.56	385.04	415.43	403.15	342.85	404.26	59.73	0.94	0.69	0.91
Cull cows	114.52	58.06	56.70	52.62	89.93	72.34	37.19	64.51				
Weaned calves	565.66	602.68	608.26	593.18	505.95	526.54	575.29	558.91				
Total income	680.18	660.74	664.96	645.81	595.88	598.87	612.48	623.43	24.77	< 0.01	0.98	0.66
NCR <sup>4</sup>	231.89	291.31	288.40	260.76	180.46	195.73	269.63	219.16	54.62	0.19	0.62	0.91
Difference <sup>5</sup>		59.42	56.51	28.88		15.27	89.17	38.71				

<sup>&</sup>lt;sup>1</sup>Dams weaned in October or December.

<sup>&</sup>lt;sup>2</sup>WR0: winter range without supplement; WR1: winter range with 0.45 kg DM/cow daily 32% CP supplement; WR2: winter range with 0.91 kg DM/cow daily 32% CP supplement; CR: corn residue without supplement.

<sup>&</sup>lt;sup>3</sup>Wean: weaning date main effect; Winter: winter grazing treatment main effect; WxW: weaning date by winter grazing treatment interaction; superscripts shown only if interaction present.

<sup>&</sup>lt;sup>4</sup>Net change in return calculated by subtracting feed, transportation, and replacement female value from cull female value and value of calves at weaning or December.

<sup>&</sup>lt;sup>5</sup>Difference in net change in return relative to dams wintered on range without supplement.

**Table 11.** Effects of weaning date<sup>1</sup> and winter grazing treatment<sup>2</sup> on value of steer progeny until harvest on net change in return (\$/cow)

		Oct	ober			Dece	mber				P-value <sup>3</sup>	
Item	WR0	WR1	WR2	CR	WR0	WR1	WR2	CR	SE	Wean	Winter	WxW
Feed	341.65	346.04	335.86	353.70	350.71	332.67	352.77	350.29				
Transportation	23.30	24.83	24.35	25.34	22.65	22.80	24.60	24.66				
Total cost	364.95	370.87	360.21	379.03	373.37	355.47	377.38	374.95	6.06	0.61	0.01	< 0.01
Live value	1106.10	1164.28	1148.35	1190.54	1081.55	1091.45	1172.75	1175.30	49.78	0.29	0.02	0.46
Grid value	1117.15	1168.46	1153.94	1185.75	1103.07	1095.94	1177.09	1178.94	52.30	0.42	0.08	0.52
Live NCR <sup>4</sup>	741.15	793.41	788.14	811.50	708.18	735.98	795.37	800.34	53.96	0.24	0.03	0.70
Grid NCR <sup>4</sup>	752.20	797.59	793.73	806.72	729.71	740.47	799.71	803.99	56.81	0.36	0.13	0.74
Live difference <sup>5</sup>		52.26	46.98	70.35		27.80	87.19	92.16				
Grid difference <sup>5</sup>		45.39	41.53	54.52		10.76	70.01	74.28				

<sup>&</sup>lt;sup>1</sup>Dams weaned in October or December.

<sup>&</sup>lt;sup>2</sup>WR0: winter range without supplement; WR1: winter range with 0.45 kg DM/cow daily 32% CP supplement; WR2: winter range with 0.91 kg DM/cow daily 32% CP supplement; CR: corn residue without supplement.

<sup>&</sup>lt;sup>3</sup>Wean: weaning date main effect; Winter: winter grazing treatment main effect; WxW: weaning date by winter grazing treatment interaction; superscripts shown only if interaction present.

<sup>&</sup>lt;sup>4</sup>Net change in return calculated by subtracting net change in return from cows in December, feed and transportation from live or grid value; assumed no weaned calf crop in December.

<sup>&</sup>lt;sup>5</sup>Difference in net change in return relative to dams wintered on range without supplement.