



# BEEF CATTLE AND RANGE

RESEARCH REPORT

Carrington Research Extension Center  
Central Grasslands Research Extension Center  
Department of Animal Sciences  
Department of Veterinary and Microbiological Sciences  
Hettinger Research Extension Center  
N.D. Agricultural Experiment Station  
NDSU Extension Service  
North Dakota State University

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# Duck production on post-contract Conservation Reserve Program grasslands in southwestern North Dakota

B.A. Geaumont<sup>1,2</sup>, E. Sebesta<sup>1,2</sup>, K.K. Sedivec<sup>1</sup> and C.S. Schauer<sup>2</sup>

*The objective of this study was to evaluate the effect of multiuse land management systems on post-Conservation Reserve Program lands and demonstrate the potential viability and sustainability of producing both agricultural and wildlife outputs. Our findings suggest that occasional grazing or moderate levels of grazing pressure of Conservation Reserve Program grasslands may decrease duck hen recruitment but improve duck nesting success.*

## Summary

The objective of this study was to evaluate the effect of multiuse land management systems on post-Conservation Reserve Program lands and demonstrate the potential viability and sustainability of producing both agricultural and wildlife outputs. Six species of ducks utilized research plots as nesting cover, with the highest nest densities occurring in idled land (7.1 nests/100 acres). Overall nest success was highest in the seasonlong grazed pasture at 60 percent success. Our study provides additional evidence to support the importance of permanent cover as nesting habitat for ducks. However, our data also supports earlier findings of higher nesting success rates in seasonlong pastures versus idled lands. Our findings suggest that occasional grazing or moderate levels of grazing pressure of Conservation Reserve Program grasslands may decrease hen recruitment but improve nesting success. Moderately grazed lands may compensate for decreased nest density through increased nest success or may even improve duck production efficiency.

## Introduction

The importance of the Prairie Pothole Region (PPR) in North Dakota for duck production has been well-established (Smith et al., 1964). The PPR is composed of numerous wetlands of various classifications that provide exceptional brood-rearing habitat in most years. A plethora of research has focused on duck production within the region; however, little research regarding duck production has been done outside the PPR.

The importance of permanent cover as nesting habitat has been well-documented for ducks (Kruse and Bowen, 1996; Stephens et al., 2005). The Conservation Reserve Program (CRP) has provided millions of acres of permanent cover, restored thousands of wetland acres and protected other wetland habitats throughout the United States. Reynolds et al. (2001) reported 23 percent of duck nests were successful in CRP cover and suggest that CRP has increased duck recruitment by 30 percent in the PPR. Given these findings, CRP grasslands outside the PPR may be expected to provide even more valuable nesting cover for ducks.

Livestock production, although not common on CRP lands due to regulation, is a common land use of many permanent cover types throughout much of the Dakotas. The effects of grazing on duck production have been evaluated with mixed

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<sup>1</sup>School of Natural Resource Sciences, North Dakota State University, Fargo, N.D. 58105

<sup>2</sup>Hettinger Research Extension Center, North Dakota State University, Hettinger, N.D., 58639.

results (Kirsch, 1969; Barker et al., 1990; Ignatiuk and Duncan, 2001). Although duck production and its interaction with livestock have been investigated in the PPR, few studies have focused on this relationship outside the region.

The Hettinger Research Extension Center (HREC) began a research trial evaluating a multiple land use strategy on post-contract CRP lands and its effect on ring-necked pheasant (*Phasianus colchicus*) production in 2006. A total of 156 duck nests were monitored from 2006 through 2008. This report documents the effects of the multiple land use strategy on duck production.

## Procedures

Study sites were located in Adams County, which is in southwestern North Dakota. Both study sites were within three miles of Hettinger, N.D. Each study site consists of approximately 640 acres. A randomized complete block design was used to test if nest success and nest density of ducks were different among several land uses. Each 640-acre study site was divided into one seasonlong (SL) pasture 320 acres in size. The other four treatments were 80 acres in size and were assigned the following treatments or control: no-till barley (NTB), no-till corn (NTC), hayed (HAY) or idle (ID) control.

The SL was grazed with 33 to 45 Angus x Hereford cows from June 1 to Jan, 1 each year, targeting a 50 percent degree of disappearance of forage. Stocking densities were adjusted each year to achieve approximately the targeted use. The HAY was harvested annually during the second week in July. The NTB was harvested for forage and NTC was grazed from Jan. 1 to

April 1, at which time the cows were returned to the HREC for calving and fed harvested feeds until June 1. The ID remained intact to represent continuation of CRP, with no forage harvested, and provide habitat for ducks, pheasant and other wildlife. The NTC and NTB treatments were rotated between the two selected 80-acre parcels annually to represent traditional crop rotations.

Duck utilization of each land management type (SL, NTB, NTC, HAY and ID) was determined using a technique described by Higgins et al. (1969). Duck nests were located by dragging a 100-foot chain, 0.31 inch in diameter, between two all-terrain vehicles. The presence of a nest was determined when a hen was flushed from her nest. Each study site was searched in its entirety once every two weeks beginning in late April or early May and continuing until July 15 to determine the presence of nests and timing of the primary nesting season. Upon locating each nest, time of nest initiation was determined utilizing a candling technique (Weller 1956). Each nest was revisited every three to five days to determine nest fate.

Duck nest success was calculated using a modified Mayfield method as described by Miller and Johnson (1978). A nest was considered successful when at least one chick hatched and left the nest. Mean nest density was calculated for each treatment. A repeated measure ANOVA using PROC MIXED was used to analyze egg initiation data. The null hypothesis tested was that no difference in nest success or density would occur among treatments and years. A  $P$ -value  $\leq 0.05$  was considered significant. When a significant  $P$ -value was obtained regarding treatments, year and treatment X year interaction, the Tukey's Honesty Significance Test procedure was used to separate means.

## Results

The degree of herbage disappearance was lower than the target of 50 percent on all ecological sites for 2006 and 2007 (Table 1). Disappearance was greatest on the loamy overflow ecological site when compared with the loamy and shallow loamy sites in 2006 and 2007. The loamy site had a greater degree of utilization than the shallow loamy site in 2006; however, the shallow loamy site was utilized at a greater level than the loamy site in 2007. The degree of disappearance could not be calculated for 2008 due to early and prolonged snowfall during the fall.

Several species of ducks, including mallard (*Anas platyrhynchos*), gadwall (*A. strepera*), northern pintail (*A. acuta*) and blue-winged teal (*A. discors*), were observed nesting on trial plots, with gadwall being the most abundant. In general, the number of duck nests declined from 2006 to 2008. A year effect occurred between 2006 and 2007, with overall nest density lower in 2006 than 2007 ( $P \leq 0.05$ ; Table 2). The SL grazing treatment (5.1 nests/100 acres) and ID control (7.1 nests/100 acres) had greater duck nest density ( $P < 0.05$ ) than NTC and NTB (0.6 and 0.4 nests/100 acre, respectively).

Predation by skunks (*Mephitis mephitis*) and other mammalian predators accounted for the majority of nest failures. Nest failures resulted in the destruction of the nest and eggs but generally showed no signs of hen predation. Duck nest success was greater ( $P \leq 0.05$ ) on the SL (61 percent) compared with NTC (2 percent) and NTB (1 percent) (Table 3). Duck nest success on ID (41 percent) was trending toward being different from NTB and NTC ( $P = 0.09$ ).

## Discussion

Ducks predominantly chose habitats that consisted of permanent grassland cover for nest sites during the study and avoided cropped land entirely following 2006. Duck nest density was highest in ID CRP lands throughout the study period. Kirsch (1969) reported similar findings of 0.28 nest/acre in idle lands versus 0.17 nest/acre in grazed lands. Barker et al. (1990) reported greater nest densities in idle lands than grazed treatments in six of seven years in a study in south-central North Dakota.

The nest success rates recorded in this trial were high compared with most studies found in the literature. Nests initiated in the SL treatment were more successful than all other treatments, including ID. Barker et al. (1990) reported an average Mayfield nest success rate of 26.6 percent in seasonlong pastures versus 11.3 percent in idle lands from 1983 to 1989. Ignatiuk and Duncan (2001) found duck nests initiated in seasonlong pastures averaged 25 percent success in Saskatchewan. Conversely, Kirsch (1969) reported higher apparent success rates in idled lands (28 percent) versus grazed (14 percent). Stocking rates in our study, as well as those in Barker et al. (1990) and Ignatiuk and Duncan (2001), were designed to achieve a 50 percent degree of disappearance, while those in Kirsch (1969) varied, often exceeding 50 percent disappearance.

As with earlier research, nest success did not appear to be impacted negatively by the presence of cattle. Many opinions have been offered as

to why this phenomenon may occur, but the likely answer is cattle presence discourages predators, either directly or indirectly. Although the ability to graze CRP is limited by federal CRP requirements, future agriculture and land management considerations may want to be given to the occasional grazing of CRP. When proper stocking

rates are applied, which allows for residual vegetation to remain following the completion of grazing, ducks may initiate fewer nests. However, nests initiated in properly stocked seasonlong pastures are more likely to have greater nesting success and potentially more ducklings produced than idled lands.

**Table 1. Degree of herbage disappearance (percent) for the loamy, loamy overflow and shallow loamy ecological sites near Hettinger, N.D., in 2006 and 2007.**

| Ecological Site | 2006        |             | 2007       |             |
|-----------------|-------------|-------------|------------|-------------|
|                 | Grass       | Forbs       | Grass      | Forbs       |
| Loamy           | 45.2 ± 10.4 | 32.4 ± 7.6  | 28.0 ± 6.8 | 70.0 ± 10.0 |
| Loamy Overflow  | 53.7 ± 1.6  | 21.2 ± 0.0  | 44.2 ± 8.8 | 50.0 ± 0.0  |
| Shallow Loamy   | 27.5 ± 15.0 | 39.8 ± 10.6 | 31.3 ± 8.5 | 80.0 ± 10.0 |

**Table 2. Mean values of duck nest density (nests/100 acre) on NTC, NTB, HAY, SL, treatments and ID control on post-Conservation Reserve Program lands near Hettinger, N.D., 2006-2008.**

| Year(s)           | Treatment <sup>1</sup> |                  |                   |                  |                  |
|-------------------|------------------------|------------------|-------------------|------------------|------------------|
|                   | SL                     | ID               | HAY               | NTC              | NTB              |
| 2006-2008         | 5.1 <sup>a</sup>       | 7.1 <sup>a</sup> | 2.9 <sup>ab</sup> | 0.6 <sup>b</sup> | 0.4 <sup>b</sup> |
| 2006 <sup>2</sup> | 5.8                    | 8.7              | 5.6               | 1.9              | 1.3              |
| 2007              | 4.4                    | 5.7              | 1.7               | 0                | 0                |
| 2008              | 5.2                    | 7.0              | 1.3               | 0                | 0                |

<sup>1</sup>Treatment abbreviations: SL = seasonlong grazing, ID = idle, HAY = hay lands, NTC = no-till corn, NTB = no-till barley.

<sup>2</sup>The HAY treatment was idle prior to study initiation and not hayed until mid-July, thus reacting like an idle treatment during the primary nesting season in 2006.

<sup>a,b</sup>Means within rows having differing superscripts differ  $P \leq 0.05$ .

**Table 3. Mean nest success (percent) on NTC, NTB, HAY, SL and ID treatments on post-Conservation Reserve Program lands near Hettinger, N.D., in 2006 and 2007.**

| Year(s)   | Treatment <sup>1</sup> |                  |                  |                |                |
|-----------|------------------------|------------------|------------------|----------------|----------------|
|           | SL                     | ID               | HAY              | NTC            | NTB            |
| 2006-2008 | 61 <sup>a</sup>        | 41 <sup>ab</sup> | 29 <sup>ab</sup> | 2 <sup>b</sup> | 1 <sup>b</sup> |
| 2006      | 56                     | 29               | 57               | 0              | 0              |
| 2007      | 62                     | 70               | 32               | 0              | 0              |
| 2008      | 66                     | 25               | 0                | 0              | 0              |

<sup>1</sup>Treatment abbreviations: SL = seasonlong grazing, ID = idle, HAY = hay lands, NTC = no-till corn, NTB = no-till barley.

<sup>a,b</sup>Means within rows having differing superscripts differ  $P \leq 0.05$ .

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# Cost-effective alternative forages for fall and winter grazing

B.W. Neville<sup>1</sup>, G.P. Lardy<sup>1</sup>, D.L. Whitted<sup>2</sup> and K.K. Sedivec<sup>2</sup>

*The objective of this research was to evaluate the economic potential of annual forages as alternatives for fall and early winter grazing in North Dakota. Choosing an annual forage with low input costs that produces more tonnage per acre will increase the cost-effectiveness of winter grazing systems.*

## Summary

The objective of this research was to evaluate the economic potential of annual forages as alternatives for fall and early winter grazing in North Dakota. Three different annual forages were tested during two years. Treatments were: 1) café, which was a mixture of multiple annual species, 2) foxtail millet, 3) turnips and 4) control, which was native range. Cattle performance, forage production and forage quality data was collected in both 2007 and 2008. No differences in animal performance were found in either year of this study. As such, the focus of this paper is on the forage production and economics.

Grazing costs on a \$/head/day basis show that turnips are consistently the least expensive forage tested in this research, averaging 83 cents/head/day during the two years. However, foxtail millet shows promise if adequate forage production can be obtained, as in the case of 2007, when our grazing cost was 76 cents/head/day on this treatment. The low stocking rate (0.3 head/acre) required for proper management makes grazing native range in the winter more expensive compared with grazing annuals such as turnips or foxtail millet. Annual mixtures such as the café treatment require additional research to increase forage production and decrease seed costs to be more economically viable. Annual forages with low input costs and good forage production will increase the cost-effectiveness of winter grazing systems.

## Introduction

Livestock producers continually try to extend the grazing season with the knowledge that extending grazing reduces feed costs (D'Souza et al., 1990; Adams et al., 1994). Allowing cattle to graze stockpiled perennial forages decreased the amount of hay needed to maintain body condition (Hitz and Russell, 1998). Grazing annual forages is an alternative way to graze livestock longer into the fall or early winter, but it also provides potentially higher quality forages. The overall objective of this study was to determine the effects of annual forage type on beef cow performance under grazing conditions during the fall and early winter in North Dakota. However, all animals performed similarly, thus the economic and forage production values of these different forages have become of great interest. This report will attempt to provide a better understanding of advantages of each of the forages tested from an economic and forage production standpoint.

## Procedures

### Forage establishment

*2007 season:* Seeding of annual forages occurred on July 13. Seeding rates for foxtail millet and turnips were 20 and 3.5 pounds per acre (lb/ac), respectively. The cafeteria treatment (café) was seeded with a seed mixture containing 20, 15, 4, 1, 1 and 0.5 lb/ac for soybeans, cowpeas, foxtail millet, sunflowers, radishes and turnips,

<sup>1</sup>Department of Animal Sciences, North Dakota State University, Fargo, N.D.

<sup>2</sup> School of Natural Resource Sciences, North Dakota State University, Fargo, N.D.

respectively. Fertilizer at 50 lb/ac (half urea, half nitrogen 11: P 52 by weight) was applied at time of seeding. Rainfall events totaled 2.99, 3.95, 2.02 and 1.5 inches/month for July, August, September and October, respectively (NDAWN, 2009). Forage sampling for production data was conducted on Oct. 4 prior to grazing.

*2008 season:* In 2008, one-half of each paddock was planted to forage barley, which was to be removed as a hay crop prior to seeding of the winter annuals. Two varieties of barley were used: Stockford and Hayes, each representing one-fourth of the total paddock. Barley was seeded (100 lb/ac) in early May and was swathed and baled in early July. Prior to harvest, 10 0.25 m<sup>2</sup> plots were clipped for each variety in each paddock. Total dry-matter (DM) forage production as well as nutrient analysis subsequently was obtained from these samples.

Seeding of annual forages for grazing occurred on July 27. Seeding rates for foxtail millet and turnips were 20 and 3 lb/ac, respectively. The cafeteria treatment (café) was seeded with a seed mixture containing 15, 4, 1.5, 1, 1 and

1 lb/ac of triticale, sorghum, red clover, sunflowers, radishes and turnips, respectively. Fertilizer (50 lb/ac urea) was applied at time of seeding. Rainfall events totaled 0.13, 5.01, 2.91, 2.44, 2.87 and 3.22 inches/month for May, June, July, August, September and October, respectively (NDAWN, 2009).

Forage sampling for production data was conducted on Oct. 6 prior to grazing. All forage samples were analyzed for crude protein, acid and neutral detergent fiber, calcium, phosphorus, and *in vitro* organic matter and dry-matter disappearance.

### Economic analysis

Rental and custom rates were used to calculate the cost of forage establishment for an economic comparison. The land rental rates used were \$14.90 and \$16.50/acre for nonirrigated pasture, as well as \$27.10 and \$30.40/acre for nonirrigated cropland in 2007 and 2008, respectively (NASS, 2008). Custom rates for tillage, drilling and fertilizer application were determined from NASS (2007).

## Results and Discussion

No differences in animal performance were found in either year of this study. As such, the focus of this paper is on the forage production and economics. The variable and fixed costs that will serve as our basis for comparison are outlined in Table 1. Seed and fertilizer costs increased from 2007 to 2008. For example, foxtail millet seed increased in cost by 30 percent and turnip seed increased by 138 percent compared to prices for similar seed in 2007. The cost of the café mixture decreased in price from 2007 to 2008. This was due to differences in species included in the mix (elimination of soybeans and cowpeas and inclusion of sorghum, red clover and triticale in 2008). The reason for the change in café mixture composition was based on forage production and cost of seed.

Forage production (Table 2) for foxtail millet decreased from 2007 to 2008 which likely was caused by the later seeding date in 2008. Differences in forage production of the turnip treatment are mostly related to the variety of turnip planted. In 2007, purple-top turnips were planted and the resulting biomass contained mainly

**Table 1. Input costs (\$/acre) and grazing cost (\$/head/day) for grazing various annual grazing systems in 2007 and 2008.**

| item                                   | 2007  |        |         |              | 2008  |        |         |              |
|--|-------|--------|---------|--------------|-------|--------|---------|--------------|
|  | Café  | Millet | Turnips | Native Range | Café  | Millet | Turnips | Native Range |
| <i>Variable costs, \$/acre</i>         |       |        |         |              |       |        |         |              |
| Seed                                   | 16.77 | 9.60   | 3.15    | -            | 15.10 | 12.48  | 7.50    | -            |
| Other <sup>1</sup>                     | -     | -      | 5.40    | -            | -     | -      | 4.40    | -            |
| <i>Fixed costs, \$/acre</i>            |       |        |         |              |       |        |         |              |
| Land Rent                              | 27.10 | 27.10  | 27.10   | 14.90        | 30.40 | 30.40  | 30.40   | 16.50        |
| Farming <sup>2</sup>                   | 13.38 | 13.38  | 13.38   | -            | 13.38 | 13.38  | 13.38   | -            |
| Fertilizer <sup>3</sup>                | 4.38  | 4.38   | 4.38    | -            | 12.50 | 12.50  | 12.50   | -            |
| <i>Total cost, \$/acre</i>             | 61.63 | 54.46  | 53.41   | 14.90        | 71.38 | 68.76  | 68.18   | 16.50        |
| Stocking rate, head/acre               | 0.8   | 1.7    | 1.5     | 0.3          | 1.2   | 1.2    | 2.0     | 0.3          |
| Grazing cost, \$/head/day <sup>4</sup> | 1.81  | 0.76   | 0.84    | 1.17         | 1.47  | 1.43   | 0.83    | 1.24         |

<sup>1</sup> Cost of oat straw provided to prevent digestive upset.

<sup>2</sup> Farming = Field cultivation, drilling and fertilizer application (custom rate for west-central North Dakota; NASS, 2007).

<sup>3</sup> Fertilizer = 25 lb/ac urea & 25 lb/ac 11:52 applied (2007), and 50 lb/ac urea applied (2008).

<sup>4</sup> Grazing cost = (Total cost (\$/acre) \* acres/animal) / number of days grazed.

turnip bulbs. However, in 2008, Pasja turnips were planted. Pasja turnips have substantially smaller bulbs and produce more foliage, making them better suited for grazing applications.

Grazing costs on a \$/head/day basis show that turnips were consistently the least expensive forage tested in this research, averaging 83 cents/head/day during the two years. However, foxtail millet shows promise if adequate forage production can be obtained, as in the case of 2007, when our grazing cost was 76 cents/head/day on this treatment. Changing the forage composition of the café treatment helped lower grazing costs, but further increases in forage production are needed to make this option viable for cattle owners. The low stocking rate (0.3 head/acre) required for proper management makes grazing native range in the winter more expensive compared with grazing annuals such as turnips or foxtail millet.

The use of forage barley in a double-cropping system had mixed results. The hay produced was good quality (10.7 percent crude protein) and the production was adequate (4,370 lb/ac; DM basis; Table 3). The calculated

net income was \$50.47 and \$33.04/acre for Hayes and Stockford varieties, respectively, based on a \$60/ton value for the forage barley. However, barley regrowth did impact our winter annual crops. Regrowth of forage barley dramatically decreased the production of our winter annual forages compared with the areas that were left unplanted. In the future herbicides will be sprayed to kill any barley regrowth in an effort to mitigating these effects. If successful, the double cropping system may become the preferred management system from an economical point of view.

**Table 2. Average production (lb/acre; DM basis) of forage in various annual grazing systems in 2007 and 2008.**

| item                 | Forage Production (lb/ac) <sup>1</sup> |       |
|----------------------|--|-------|
|                      | 2007                                   | 2008  |
| Café                 | 1,893                                  | 2,822 |
| Millet               | 5,058                                  | 3,103 |
| Turnips <sup>2</sup> | 1,956                                  | 4,099 |
| Native Range         | 2,709                                  | 2,504 |

<sup>1</sup> Based on clipping data from early October.

<sup>2</sup> Total production of foliage only.

**Table 3. Input cost, net income, forage production and quality of two varieties of forage barley.**

|                                | Variety |           |
|--------------------------------|---------|-----------|
|                                | Hayes   | Stockford |
| <i>Input Costs</i>             |         |           |
| Seed cost, \$/lb               | 0.27    | 0.38      |
| Land rent, \$/ac               | 30.40   | 30.40     |
| Drilling, \$/ac                | 7.95    | 7.95      |
| Swathing, \$/ac                | 7.97    | 7.97      |
| Baling, \$/bale                | 6.57    | 6.57      |
| Total cost, \$/ac              | 94.34   | 104.03    |
| Net income, \$/ac <sup>2</sup> | 50.47   | 33.04     |
| Forage production, lb/ac DM    | 4490    | 4250      |
| <i>Nutrient analysis, %</i>    |         |           |
| CP                             | 10.8    | 10.7      |
| NDF                            | 60.1    | 59.2      |
| ADF                            | 32.3    | 32.0      |
| IVDMD                          | 76.2    | 76.4      |
| Ca                             | 0.4     | 0.5       |
| P                              | 0.3     | 0.3       |

<sup>1</sup> Rental and custom rates obtained from (NASS, 2007 and NASS, 2008).

<sup>2</sup> Net income = (AsFed Forage production (ton/ac) \* \$60/ton) – Total Costs (\$/ac) of inputs.

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# Growth and attainment of puberty in calves from beef cows supplemented with linseed meal during late gestation

B.R. Ilse<sup>1</sup>, V.L. Anderson<sup>1</sup>, J.D. Kirsch<sup>2</sup>, D.S. Buchanan<sup>2</sup> and K.A. Vonnahme<sup>2</sup>

*The objective of this research was to evaluate the influence of 10 percent linseed meal (LSM) supplementation in the maternal diet during late gestation on calf growth and reproductive attainment of puberty. Linseed meal can be fed to beef cattle during late gestation without any negative effects on calf growth or attainment of puberty.*

## Summary

This study examined the effects of supplementing beef cows with phytoestrogen-rich linseed meal (LSM) during late gestation on calf growth and reproduction. Multiparous cows (n = 72) were allotted randomly to one of 12 pens, with six pens supplemented with pelleted LSM and six pens fed a control sunflower meal (SFM) pellet. Diets were formulated to be isocaloric and isonitrogenous. Treatment supplements were included in a totally mixed ration each day for the last 60 days of gestation. Steer calves (n = 41) were followed from birth to weaning (170 days of age). Heifer calves (n = 30) were followed from birth to 266 days of age. Birth weight, actual weaning weight and average daily gain (ADG) were recorded for both steer and heifer calves. On day 182 of age and every 14 days until 280 day of age, heifers were weighed, and jugular blood samples collected and serum analyzed for progesterone. Steer birth and weaning weight were not different between treatments ( $P > 0.19$ ). Steer ADG was not different due to treatment ( $P = 0.18$ ). Heifer birth and weaning weight were not different between treatments ( $P > 0.45$ ). Overall, heifer ADG was not different due to supplementation ( $P = 0.84$ ). We observed that nine heifers attained puberty before 6 months of age (four SFM and five LSM). Age at puberty (181.2 vs.  $187.0 \pm 7$  days for LSM vs.

SFM, respectively) was not affected by treatment ( $P = 0.58$ ). Supplementation of LSM during late gestation does not appear to impact growth rate in calves or the onset of puberty in heifer calves.

## Introduction

North Dakota is the national leader in flax production (U.S. Department of Agriculture, National Agricultural Statistics Service, 2008). Linseed meal (LSM) is a byproduct of flax in which the oil has been removed and commonly is used in livestock diets. Tou et al. (1998) found that 10 percent flaxseed fed to rat dams during gestation and lactation influenced reproductive parameters in the female offspring, such as decreased age to puberty and lengthened estrous cycles. Protein supplementation in beef cattle during the last trimester of pregnancy increased heifer weaning weight; adjusted 205-day weight, prebreeding weight and weight at pregnancy diagnosis; and had a positive effect on pregnancy rates of heifer calves (Martin et al., 2006). We hypothesized that 10 percent LSM supplementation of the maternal diet during late gestation would influence calf growth and reproductive development.

<sup>1</sup> Carrington Research Extension Center, North Dakota State University, Carrington, N.D.

<sup>2</sup> Department of Animal Sciences, North Dakota State University, Fargo, N.D.

## Procedures

### Animals and diets

This study was approved by the North Dakota State University Animal Care and Use Committee. At approximately 215 days of gestation, multiparous, mixed-breed cows ( $n = 72$ ) at the Carrington Research Extension Center were assigned randomly to one of two treatments: 1) 10 percent linseed meal (LSM) pelleted supplement or 2) a control supplement, sunflower meal (SFM). Pelleted supplements were offered (4.9 pounds per head per day) in a totally mixed ration (Table 1) until parturition. Cows were assigned to treatments using cow weight as a blocking criterion. Additionally calf birth weight and previous calf birth weight were equalized between treatments as much as possible. Animals were allotted to one of 12 pens, with six pens supplemented with LSM and six pens fed the SFM pellet. Diets were formulated to provide required nutrients for about a 1,477-pound late-gestation, mature beef cow as suggested by the National Research Council (NRC, 2000).

Upon parturition, cows were comingled and cow-calf pairs managed similarly. Calves were weaned at an average age of 170 days. Steer calves ( $n = 41$ ) were followed from birth to weaning (170 days of age). One steer calf was removed from the experiment for reasons unrelated to treatment. Heifer calves ( $n = 30$ ) were followed from birth to 266 days of age. Birth weight, actual weaning weight and ADG were recorded for both steer and heifer calves. On day 182 of age and every 14 days until 280 days of age, heifers were weighed, and jugular blood samples collected and serum analyzed for progesterone ( $P_4$ ) using a competitive chemiluminescent immunoassay (Immulite 1000, Siemens, Los Angeles, Calif.). Blood samples immediately were placed on

ice and serum was stored at minus 20 degrees Celsius until assayed for  $P_4$ . Progesterone concentrations of greater than 1 nanogram per milliliter (ng/ml) indicated that the heifer had reached puberty. Heifers were managed similarly and fed as suggested by the National Research Council (NRC, 2000) throughout the course of the study.

### Statistical analysis

Data were analyzed by least squares (Proc Mixed, V.9.1; SAS Inst. Inc., Cary, N.C.). The pen was the experimental unit for weaning weight, period weights, ADG and progesterone levels. The statistical model included the fixed effects of gestational diet of the cow and cow weight block.

## Results and Discussion

*Growth performance:* Steer birth and weaning weights were not affected by treatment ( $P > 0.19$ ; 97.0 vs. 98.7  $\pm$  3.13 pounds; 561.9 vs. 595.5  $\pm$  16.98 pounds, for LSM vs. SFM, respectively). Steer ADG was not different due to treatment ( $P = 0.18$ ; 2.69 vs. 2.82  $\pm$  0.07 pounds, for LSM vs. SFM, respectively). Heifer birth weight and weaning weight were not affected by treatment ( $P > 0.45$ ; 92.3 vs. 90.7  $\pm$  3.37 pounds; 529.8 vs. 553.3  $\pm$  20.48 pounds, for LSM vs. SFM, respectively). While Larson et al. (2009) reported protein supplement offered to cows during late gestation resulted in increased birth weight compared with nonprotein-

**Table 1. Late gestation cow ration and analyzed dietary composition.**

| Item                                     | LSM              | SFM   |
|--|------------------|-------|
| <i>Ingredient</i>                        |                  |       |
|  | ---Percent DM--- |       |
| Linseed Meal Pellet                      | 9.7              | -     |
| Sunflower Meal Pellet                    | -                | 9.7   |
| Light Barley                             | 27.6             | 27.6  |
| Straw                                    | 32.8             | 32.8  |
| Corn Silage                              | 29.9             | 29.9  |
| <i>Analyzed dietary nutrient content</i> |                  |       |
| DM, %                                    | 88.93            | 89.45 |
| CP, %                                    | 37.40            | 37.77 |
| ADF, %                                   | 19.18            | 21.78 |
| CE, %                                    | 15.34            | 17.43 |
| NE <sub>m</sub> ,/lb                     | 0.81             | 0.82  |
| NE <sub>g</sub> ,/lb                     | 0.53             | 0.53  |
| Fat, %                                   | 3.21             | 3.82  |
| Ca, %                                    | 0.43             | 0.42  |
| P, %                                     | 0.99             | 1.04  |

<sup>a</sup> Supplements were offered at 4.9 lb./head/day.

<sup>b</sup> Mineral was offered in ration to meet NRC (2000) recommended requirements.

**Table 2. Steer calf performance from cows supplemented with LSM or control diet during last 60 days of gestation.**

| Item                      | LSM   | SFM   | St Error | P-value |
|---------------------------|-------|-------|----------|---------|
| Birth Date, Julian        | 91.0  | 87.3  | 2.58     | 0.41    |
| Birth Wt, lb              | 97.0  | 98.7  | 3.13     | 0.72    |
| <i>Growth performance</i> |       |       |          |         |
| Weaning Wt, lb (day 170)  | 561.8 | 595.5 | 16.98    | 0.20    |
| ADG, lb                   | 2.69  | 2.82  | 0.071    | 0.18    |

supplemented calves, Stalker et al. (2006) found supplementation of 42 percent crude protein (CP) vs. no CP supplement prepartum in beef cows did not affect birth weight, but calves born from supplemented cows had greater weaning weights. Conversely, Tou et al. (1998) reported lighter birth weights in rat offspring born from rat dams supplemented with 10 percent flaxseed. Overall, heifer ADG was not significantly affected by supplementation ( $P = 0.84$ ; 1.83 vs. 1.85 ± 0.11 pounds, for LSM vs. SFM, respectively).

*Puberty:* We observed that nine heifers attained puberty before 6 months of age (four SFM and five LSM). Age at puberty (181.2 vs. 187.0 ± 7 days, for LSM vs. SFM, respectively) was not significantly affected by treatment ( $P = 0.58$ ). Age at puberty was earlier than previously reported (Wiltbank et al., 1969; Martin et al., 2006). Tou et al. (1998) reported that 10 percent supplemented flaxseed in rat dam diets fed during gestation and lactation decreased age to puberty, lengthened the estrous cycle and resulted in persistent estrus in offspring. Due to the unanticipated early age of puberty measured at  $P_4 > 1.0$  ng/ml, conclusions cannot be made regarding treatment effects on actual date of puberty.

**Table 3. Heifer performance born from cows supplemented with LSM or control diet during last 60 days of gestation.**

| Item                            | LSM   | SFM   | St Error | P-value |
|---------------------------------|-------|-------|----------|---------|
| Birth Date, Julian              | 93.2  | 89.2  | 2.42     | 0.32    |
| Birth Wt, lb                    | 92.3  | 90.7  | 3.37     | 0.74    |
| Growth performance              |       |       |          |         |
| Weaning Wt, lb (day 170)        | 529.8 | 553.6 | 20.48    | 0.45    |
| Wt Initial, lb (day 182)        | 546.5 | 571.0 | 18.30    | 0.38    |
| Wt Mid, lb (day 226)            | 625.5 | 649.6 | 17.79    | 0.38    |
| Wt End, lb (day 280)            | 707.7 | 732.4 | 18.54    | 0.38    |
| ADG Initial, lb (days 170-182)  | 1.19  | 1.28  | 0.26     | 0.83    |
| ADG Mid, lb (days 182-226)      | 2.51  | 2.65  | 0.22     | 0.68    |
| ADG End, lb (days 226-280)      | 1.30  | 1.32  | 0.18     | 0.97    |
| Overall ADG                     | 1.83  | 1.85  | 0.11     | 0.85    |
| Heifer Age at Puberty           |       |       |          |         |
| Day of Age, Julian <sup>a</sup> | 181.2 | 187.0 | 7.01     | 0.58    |

<sup>a</sup> Day of age at puberty was determined when  $P_4$  blood serum was > 1 ng/ml.

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# Effect of cobalt supplementation on performance of lactating beef cows and creep-fed calves

Vern Anderson<sup>1</sup>, Ron Dvorak<sup>2</sup> and Breanne Ilse<sup>1</sup>

*Cobalt supplementation of cows and calves during late lactation did not alter performance when cows were fed a diet that met their nutrient requirements, although the cobalt treatment produced an advantage in cow weight change during the initial feeding period.*

## Summary

Beef cows in late lactation and their creep-fed calves (n = 85) were used to evaluate the effects of supplemental cobalt on performance. Cobalt in CoMax is represented to be more soluble, which would contribute to more rapid uptake by microbes in the rumen. The drylot cows were fed a diet of wheat straw, distillers grain and barley malt sprouts with a commercial trace mineral supplement. Cows receiving supplemental cobalt lost less weight during the first 28 days of the trial but overall, weight change was not different in the cows. Calves in both treatments consumed the same amount of creep feed and gained the same with equal feed conversion.

## Introduction

Efficiency in beef cattle production is determined by comparing the amount of feed consumed versus pounds gained. Appropriate levels of energy and protein will provide efficient growth to achieve the genetic potential. The rumen consists of a mosaic of microbes consisting of bacteria, fungi and protozoa. The health and well-being of these organisms, especially bacteria, have a direct effect on the digestion of forages. Rumen bacteria have a strong affinity for cobalt, with rapid uptake when it is present in an available form. A new commercial product, CoMax from Ralco Nutrition Inc., Marshall, Minn., reportedly provides highly rumen-soluble cobalt

for ruminal microbes. Little data exists on the effect of this supplement in a beef cow-calf enterprise, especially during late lactation when milk production decreases and calf growth potential exceeds milk production. This study was conducted to evaluate the effects of supplementing cows and their calves with cobalt during late lactation.

## Experimental Procedures

Red Angus crossbred beef cows (n = 85) and their nursing calves were allotted by calf date of birth, dam weight and sex of calf to one of four pens, with two pens assigned to each treatment. The treatments were: a) control, no CoMax fed to cows or calves, and b) cobalt, CoMax supplement fed to both cows and calves. The CoMax product was included in a manufactured feed supplement at 4 grams per pound. The supplement was fed at 1 pound (4 grams CoMax) per head per day to lactating cows and 4 ounces (1 gram CoMax) per head per day to calves mixed in the creep feed. The control group received the same supplement formulated without CoMax. CoMax contains cobalt carbonate, calcium carbonate, lactic acid, fenugreek flavor, diatomaceous earth, and hydrated calcium and sodium aluminosilicates.

A pelleted creep feed formulated with 50 percent wheat midds, 39 percent field peas and 11 percent dry distillers grain was manufactured by G & R

<sup>1</sup>Carrington Research Extension Center, North Dakota State University, Carrington, N.D.

<sup>2</sup>Ralco Nutrition Inc., Marshall, Minn.

Grain and Feed, New Rockford, N.D. This creep feed was mixed with the treatment supplements, chopped straw and condensed separator byproduct in a total mixed ration and fed to appetite in calf bunks in a separate creep feed area of each pen. Feed intake was recorded daily. Cow diets included wet distillers grain, wheat straw and barley malt sprouts plus the treatment supplement. The cow ration met or exceeded nutrient requirements (National Research Council, 1996) for beef cows in late lactation.

Cows and calves were weighed individually at the start and end of the 56-day trial and an intermediate weight was taken on the calves on day

28. Feed efficiency was calculated for each of the 28-day weigh periods for the calves. All pairs were fed in open drylot pens equipped with automatic waterers and fence line bunks, which allowed for 2 feet of bunk space per head. This study was initiated after the breeding season concluded and was terminated at weaning. The protocol for this study was approved by the NDSU Institutional Animal Care and Use Committee.

## Results

Cows commonly lose weight during lactation due to requirements for milk production. During period one of this trial, control cows lost more weight

( $P = 0.02$ ) than cobalt-supplemented cows (Table 1) although the weight change was similar ( $P = 0.47$ ) during the entire trial. Cobalt cows gained 0.33 pound per day vs. 0.22 pound for the control cows during the study period. No differences were detected in calf gains ( $P \geq 0.58$ ) during either of the periods or overall (2.95 vs. 2.92 pounds for control and cobalt supplement, respectively (Table 2). The calf gains improved from period one to period two, probably a reflection of the increase in creep feed intake (Table 2). Creep feed intake ( $P = 0.35$ ) and feed efficiency ( $P = 0.64$ ), expressed as feed:gain, were not affected by supplemental cobalt.

## Discussion

The cobalt requirement of ruminants is not well-defined, but recent evidence indicates cobalt is important to vitamin B12 synthesis, which is a critical factor in the pathway converting propionate to glucose. Factors that may affect response to supplemental cobalt include the obvious: cobalt content and form. Diets with marginal or deficient energy levels also may benefit from organic cobalt, with improved energy from glucose synthesis. In addition, the balance of starch and fiber to keep a rumen at a stable state is critical, and marginal conditions in the rumen from high-grain diets may result in a positive response from cobalt. High-grain finishing diets that create low ruminal pH may benefit from cobalt to maintain healthy bacterial populations. Tiffany et al. (2003) observed that supplementing

**Table 1. Cow performance during late lactation with and without cobalt supplement in the ration.**

| Item                           | Treatment |        |            | P value |
|--------------------------------|-----------|--------|------------|---------|
|                                | Control   | Cobalt | Std. Error |         |
| Initial wt, lb, Aug. 7, 2007   | 1,390     | 1,405  | 20.98      | 0.60    |
| Period 1 wt, lb, Sept. 6, 2007 | 1,373     | 1,405  | 21.62      | 0.30    |
| Period 2 wt, lb, Oct. 4, 2007  | 1,402     | 1,423  | 22.17      | 0.50    |
| Period 1 ADG, lb               | -0.55     | -0.01  | 0.23       | 0.02    |
| Period 2 ADG, lb               | 1.07      | 0.70   | 0.25       | 0.14    |
| Overall ADG, lb                | 0.22      | 0.33   | 0.15       | 0.47    |

ADG – average daily gain.

**Table 2. Calf performance with creep feed with and without cobalt supplement.**

| Item                           | Treatment |        |            | P value |
|--------------------------------|-----------|--------|------------|---------|
|                                | Control   | Cobalt | Std. Error |         |
| Initial Wt, lb, Aug. 7, 2007   | 437.9     | 448.8  | 8.83       | 0.39    |
| Period 1 wt, lb, Sept. 6, 2007 | 522.3     | 533.4  | 9.96       | 0.43    |
| Period 2 wt, lb, Oct. 4, 2007  | 606.2     | 615.5  | 11.48      | 0.57    |
| Period 1 ADG, lb               | 2.81      | 2.82   | 0.09       | 0.95    |
| Period 2 ADG, lb               | 3.11      | 3.04   | 0.13       | 0.58    |
| Overall ADG, lb                | 2.95      | 2.92   | 0.09       | 0.74    |
| Period 1 DMI, lb               | 10.95     | 11.22  | 0.18       | 0.41    |
| Period 2 DMI, lb               | 13.29     | 14.12  | 0.45       | 0.33    |
| Overall DMI, lb                | 12.12     | 12.67  | 0.32       | 0.35    |
| Period 1 Feed:Gain             | 3.91      | 3.99   | 0.23       | 0.82    |
| Period 2 Feed:Gain             | 4.30      | 4.66   | 0.35       | 0.55    |
| Overall Feed:Gain              | 4.21      | 4.35   | 0.29       | 0.64    |

ADG – average daily gain.

DMI – dry-matter intake.

feedlot cattle with cobalt increased ruminal propionate, feed intake and daily gains during finishing. Tiffany and Spears (2005) report that cobalt supplementation increased feed intake and gain in finishing cattle. They theorize that diets marginally deficient in cobalt may reduce feed intake and subsequent gains. In an unpublished commercial feedlot study, a 10.7 percent improvement in gain was observed when CoMax was added to the ration.

Only anecdotal data is available for cow-calf production, with field reports of significant increase in weaning weights. Nutrient availability in the diet may have a significant effect on the usefulness of the supplement. Marginal energy diets supporting less than adequate glucose synthesis, such as mature native grasses or corn stalks, may benefit more from cobalt supplementation. Miller-Webster and Hoover (2006) observed increased digestion of organic matter, acid detergent fiber and neutral detergent fiber in stocker calves grazing cornstalks. Genetically, calf growth potential typically exceeds nutrients supplied in the dams' milk at about 120 days of age when this trial was initiated. Nutrients in the rations fed appear to provide adequate energy and protein to maintain a healthy and stable rumen environment in both cows and calves.

Further work is justified to explore the appropriate timing, diet conditions and potential benefits of supplemental cobalt for ruminants.

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# Effects of mineral supplementation and inorganic vs. organic mineral sources on liver and blood serum levels and performance of beef cows and their calves

V.L. Anderson<sup>1</sup>, B.R. Ilse<sup>1</sup> and C.S. Schauer<sup>2</sup>

*Mineral levels tested using blood serum and liver biopsies indicate copper is the mineral most susceptible to deficiency in the cow herd at the Carrington Research Extension Center. Depletion and different supplementation treatments did not affect cow or calf performance but did improve copper status.*

## Summary

Mature beef cows (n = 68) were allotted to one of three treatments to evaluate mineral supplementation strategies. After a nine-month period in which no minerals were fed, mature crossbred beef cows were allotted to a control (no mineral), inorganic or organic mineral supplement from post-calving until weaning. Copper was the only mineral observed to be depleted to near deficiency, but either inorganic or organic mineral treatments increased copper stores in the liver. No differences in cow or calf performance were observed due to mineral treatments; however, long-term production may be affected without proper mineral nutrition.

## Introduction

Cattle producers spend significant amounts of money on mineral supplements. Substantial variation in mineral status can occur due to cow diet, productivity, soils (glaciated or nonglaciated areas), weather and other factors. Anecdotal information indicates that some herds are not supplemented with minerals other than white salt and are productive and healthy. Conversely, some herds provided more complex mineral supplements may have conception and herd health issues. Mineral nutrition is specific to location and feeding/management practices. Metzger et al. (2007) report performance data

and mineral costs for 125 beef herds enrolled in the North Dakota Farm Business Management Program. Mineral costs per cow ranged from \$8.81 in the 20 percent least profitable herds to \$18.65 for the 20 percent most profitable herds. With high feed costs and marginal net returns, mineral supplementation often is reduced or eliminated. This study was conducted to evaluate mineral nutrition and supplementation in North Dakota beef cows.

## Experimental Procedures

After weaning in October 2005, all mineral supplementation was terminated for the mature crossbred beef cow herd at the Carrington Research Extension Center to “draw down” mineral stores. Cows grazed crop aftermath and mature slough grasses for approximately two months before winter pen feeding began. The gestating cow diet for the winter was primarily crop residue and coproducts to meet National Research Council (NRC) (1996) nutrient requirements. The diet consisted of wheat straw, corn silage, wheat midds or wheat screenings and distillers grain. The coproducts were mixed with silage and chopped straw and fed in fence line bunks. Ring feeders were filled with big round bales of wheat straw to allow free-choice access. Cows were managed together until after calving in March and April 2006.

<sup>1</sup> Carrington Research Extension Center, North Dakota State University, Carrington, N.D.

<sup>2</sup> Hettinger Research Extension Center, North Dakota State University, Hettinger, N.D.

At the completion of calving, mature crossbred beef cow-calf pairs (n = 68) were allotted randomly by calf birth date, cow weight and calf sex to one of three mineral supplementation treatments. The treatments consisted of: 1) control - no mineral (CON), 2) inorganic (INORG) or 3) organic or chelated (ORG). Cows were penned in treatment groups with the pen as the experimental unit. The base formulation for both mineral treatments was the same commercial “12-6” (calcium-phosphorous) mineral product manufactured by CHS Payback Feeds, Edgeley, N.D. Four organic minerals were included in the ORG supplement, including zinc methionine; cobalt glucoheptonate; and amino acid complexes of zinc, manganese and copper. Mineral supplements were fed at 3 ounces per head daily mixed into the cow ration. The cow lactation ration consisted of (dry-matter basis) 43 percent millet/wheat straw, 17 percent corn silage, 17 percent wet distillers grain, 10 percent chopped alfalfa hay and 10 percent barley sprouts/screenings. This diet met or exceeded NRC (1996) nutrient requirements for lactating beef cows.

Cows were exposed to natural service sires for 45 days starting June 10. Calves were creep fed at equal intake levels per head with feed added at two-day intervals. The creep feed formulation on a dry-matter basis was 36 percent pelleted soyhulls, 36 percent rolled field peas, 18 percent pelleted wheat midds, 7 percent chopped grass hay and 3 percent vitamin/inorganic mineral supplement. At weaning, all cows were comingled and allowed to graze crop aftermath and fed INORG mineral during the winter feeding period. Cows were monitored until calving the following year to observe any carryover effects of the mineral treatment regimes

on performance. This project was approved by the NDSU Institutional Animal Care and Use Committee.

*Animal Performance:* Cow performance was measured by weight and body condition score (BCS). Cows were weighed and scored individually at the initiation and termination of the mineral feeding period (May and October 2006). A1-to-9 scale was used for BCS determination, with three people scoring each cow and the mode used as the score (Wagner et al., 1988). All cows were observed monthly to determine any visual symptoms of mineral deficiency, including faded hair coat, lethargy, hair loss, normal healthy vigor and general health condition. Calf performance was measured by weight gain from the initiation of the study in May until weaning in October. 2007 calving data were recorded to determine any residual effect of mineral treatment on calving problems or observable symptoms of mineral deficiency.

*Serum sampling and liver biopsy:* To determine changes in physiological mineral status of the cows, a subsample (n = 10) from each treatment group was selected randomly for blood and liver sampling procedures. Blood was

collected via jugular venipuncture, centrifuged, decanted into serum tubes, frozen and sent to the analytical laboratory at the Michigan State University Diagnostic Center for Population and Animal Health. Serum was used to measure the circulating mineral levels. To determine change in stored mineral status, liver biopsies were performed according to procedures recently published by Herdt (2009) with a TruCut biopsy trocar on a subsample of cows (n = 6) within the serum collection group for each treatment. Biopsies were conducted on the same cows at the start and end of the mineral feeding period.

## Results and Discussion

*Cow performance:* The effects of mineral supplementation on cow performance are shown in Table 1. Initial weight of the cows was not different ( $P = 0.23$ ,  $1,281 \pm 28.91$  pounds); however, the ORG cows weighed 20 pounds more than the control cows and 70 pounds more than the inorganic cows. Final cow weight was not different among treatment groups ( $P = 0.56$ ).

However, cows receiving the organic mineral supplement gained less weight ( $P = 0.01$ ) in comparison with

**Table 1. Cow performance for different mineral supplementation programs.**

| Item                                | No Mineral        | Inorganic         | Organic           | SEM <sup>c</sup> | P value |
|-------------------------------------|-------------------|-------------------|-------------------|------------------|---------|
| Initial Wt , lb<br>May 31, 2006     | 1,241             | 1,292             | 1,310             | 28.91            | 0.23    |
| Final Wt , lb<br>Oct. 24, 2006      | 1,358             | 1,396             | 1,393             | 27.34            | 0.56    |
| Wt change, lb                       | 117 <sup>a</sup>  | 104 <sup>a</sup>  | 71 <sup>b</sup>   | 10.41            | 0.01    |
| BCS*<br>May 31, 2006                | 5.07 <sup>a</sup> | 4.71 <sup>b</sup> | 5.22 <sup>a</sup> | 0.10             | 0.01    |
| BCS*<br>Dec. 22, 2006               | 5.34              | 5.55              | 5.48              | 0.07             | 0.11    |
| BCS* Change                         | 0.27 <sup>a</sup> | 0.83 <sup>b</sup> | 0.24 <sup>a</sup> | 0.10             | 0.01    |
| Calving interval, days<br>2006-2007 | 371.6             | 370.6             | 369.3             | 5.77             | 0.49    |

\*BCS Body condition score system is based on 1-to-9 scale.

<sup>a,b</sup> Means within rows having different superscripts differ  $P < 0.05$ .

<sup>c</sup> Standard error of the mean, n = 22-23 observations per treatment.

cows fed the inorganic or no mineral treatments, respectively ( $71.2 \pm 11.1$  pounds;  $104.1 \pm 10.8$  pounds;  $116.8 \pm 10.4$  pounds). Body condition score changed through time in respect to the treatment groups, with INORG cows increasing the most. This observation must be considered in light of the INORG cows' significantly lower BCS at the initiation of the mineral feeding period. Those cows may have experienced some compensatory gain during lactation. Calving interval (date of calving in consecutive years) was not affected by treatment, ( $P = 0.49$ ) but the ORG cows had 2.3 days shorter interval than CON cows and 1.3 days shorter than INORG cows.

*Calf performance:* No differences in calf birth weight or gain through weaning were observed due to respective cow treatments (Table 2.). Calf birth weights in 2006 averaged 102.3, 101.8 and  $96.7 \pm 2.8$  pounds for CON, INORG and ORG treatments, respectively, while calf gains were 364.7, 366.2 and 385.5. The calving data from 2007 also showed no difference among mineral treatments, indicating no residual effect due to mineral supplementation programs, with birth weights of 98.7, 103.7 and  $99.2 \pm 2.8$ .

*Serum mineral levels:* Much discussion has focused on the best method of determining mineral status in animals. Blood serum often is used because it provides data on the circulating levels without regard to the liver storage pool, which may draw down without affecting serum levels (Underwood and Suttle, 1999). Serum mineral levels are maintained at optimum levels until body stores are depleted. This indicator is one step closer to dysfunction than stored levels in the liver. Serum levels of copper (Cu) increased in the INORG treatment ( $P = 0.04$ ); however, Cu circulating levels decreased in both the CON and

ORG groups ( $0.06 \pm 0.04$ ;  $-0.07 \pm 0.04$ ;  $-0.10 \pm 0.05$ , Table 3). None of the copper levels are considered outside the normal range, however. Normal copper levels are reported to be between 0.60

and 1.50 parts per million (ppm) (Puls, 1994). Serum phosphorus (P) decreased ( $P = 0.02$ ) in the CON and INORG groups but increased in the ORG treatment, respectively,  $-4.70 \pm$

**Table 2. Performance of calves nursing dams supplemented with different mineral programs.**

| Item                             | No Mineral | Inorganic | Organic | SEM <sup>a</sup> | P value |
|----------------------------------|------------|-----------|---------|------------------|---------|
| Calf birth wt, lb<br>Spring 2006 | 102.3      | 101.8     | 96.7    | 2.48             | 0.22    |
| Initial wt, lb<br>May 31, 2006   | 197.9      | 207.9     | 193.3   | 6.55             | 0.31    |
| Final wt, lb<br>Sept. 24, 2006   | 562.5      | 574.1     | 578.1   | 13.09            | 0.70    |
| Wt gain, lb                      | 364.7      | 366.2     | 385.5   | 8.99             | 0.23    |
| Calf birth wt, lb<br>Spring 2007 | 98.7       | 103.7     | 99.2    | 2.82             | 0.42    |

<sup>a</sup> Standard error of the mean, n = 22-23 observations per treatment.

**Table 3. Serum mineral levels for cows supplemented with different mineral programs (ppm).**

| Item                | Control            | Inorganic          | Organic            | SEM <sup>a</sup> | P value <sup>b,c</sup> |
|---------------------|--------------------|--------------------|--------------------|------------------|------------------------|
| Calcium 1           | 92.40              | 94.10              | 93.67              | 1.60             | 0.74                   |
| Calcium 2           | 93.10              | 89.70              | 83.67              | 3.48             | 0.19                   |
| Calcium $\Delta$    | 0.70               | -4.40              | -10.00             | 3.61             | 0.15                   |
| Copper 1            | 0.91               | 0.92               | 0.86               | 0.03             | 0.52                   |
| Copper 2            | 0.84 <sup>bc</sup> | 0.98 <sup>b</sup>  | 0.77 <sup>c</sup>  | 0.05             | 0.02                   |
| Copper $\Delta$     | -0.07 <sup>b</sup> | 0.06 <sup>c</sup>  | -0.10 <sup>b</sup> | 0.04             | 0.05                   |
| Iron 1              | 1.47               | 1.21               | 1.47               | 0.11             | 0.14                   |
| Iron 2              | 1.70               | 1.68               | 1.76               | 0.10             | 0.83                   |
| Iron $\Delta$       | 0.22               | 0.47               | 0.29               | 0.17             | 0.56                   |
| Magnesium 1         | 20.25              | 19.86              | 21.11              | 0.60             | 0.35                   |
| Magnesium 2         | 19.74              | 19.35              | 18.70              | 0.64             | 0.54                   |
| Magnesium $\Delta$  | -0.51              | -0.51              | -2.43              | 0.73             | 0.14                   |
| Phosphorus 1        | 67.20              | 60.70              | 58.78              | 2.52             | 0.07                   |
| Phosphorus 2        | 62.90              | 56.00              | 62.56              | 2.38             | 0.09                   |
| Phosphorus $\Delta$ | -4.30 <sup>b</sup> | -4.70 <sup>b</sup> | 3.78 <sup>c</sup>  | 2.20             | 0.02                   |
| Potassium 1         | 183.60             | 179.70             | 188.33             | 4.97             | 0.50                   |
| Potassium 2         | 183.20             | 183.30             | 193.11             | 8.80             | 0.68                   |
| Potassium $\Delta$  | -0.40              | 3.60               | 4.78               | 9.52             | 0.92                   |
| Sodium 1            | 3272               | 3522               | 3262               | 179.71           | 0.53                   |
| Sodium 2            | 3330               | 3175               | 3033               | 104.43           | 0.17                   |
| Sodium $\Delta$     | 58.00              | -347.00            | -228.89            | 194.81           | 0.34                   |
| Zinc 1              | 0.93               | 0.89               | 0.86               | 0.04             | 0.53                   |
| Zinc 2              | 1.16               | 1.28               | 1.38               | 0.07             | 0.11                   |
| Zinc $\Delta$       | 0.24               | 0.39               | 0.52               | 0.08             | 0.08                   |

1 indicates 1st serum collection May 5, 2006.

2 indicates 2nd serum collection Oct. 26, 2006.

$\Delta$  Change in mineral status.

<sup>a</sup> Standard error of the mean, n = 6 observations per treatment.

<sup>b,c</sup> Means within rows having different superscripts differ  $P < 0.05$ .

2.20;  $-4.30 \pm 2.204$ ;  $3.78 \pm 2.32$ . All phosphorous values were within the normal range. No other minerals in the serum analysis were affected by the depletion or the supplementation treatments. Thus, what may be statistically significant may not have biological implications.

*Liver tissue levels:* Liver biopsies are invasive, accompanied by some degree of risk, and require trained

personnel. They do provide a window on the status of the mineral storage pool (Underwood and Suttle, 1999). Depletion of copper stores would indicate negative mineral status in the diet. Copper appears to be the only mineral that was nearly outside the normal range as affected by the treatments (Table 4). Copper levels appear to have decreased numerically during the depletion period from

weaning in 2005 to the first biopsy in May 2006. The liver copper stores at the final biopsy in October were 29.8 ppm for the CON treatment. Liver tissue copper levels in October and the change in copper levels were significantly ( $P < 0.01$ ) greater for the INORG and the ORG vs. the CON treatment. Normal liver copper is reported at 25 to 100 ppm (Puls, 1994). The amount of change ( $P < 0.01$ ) in the copper level for the CON, INORG and ORG treatments were  $29.8 \pm 30.9$ ,  $127.6 \pm 28.6$  and  $163.5 \pm 30.9$ , respectively, from the biopsy in May until the October sampling. An extended period of CON treatment likely would have placed copper in a deficient status. No other minerals in the liver biopsies were affected by the depletion or the supplementation treatments.

*Field experience with mineral nutrition at the CREC:* Copper has been the subject of previous research at the Carrington Research Extension Center when faded hair coats were observed on cows and calves experienced slow pre-weaning growth (Casper, unpublished data) during a time of known copper deficiency. The interference of copper absorption may be especially evident with water high in iron, such as occurs at the Carrington Research Extension Center. When crop residue use increased in the year-round drylot cow diet in the CREC herd, an increase in number of retained placentas and more faded hair coats were observed. A commercial inorganic mineral mix had been fed free choice for a number of years with inconsistent intake. A more comprehensive mineral supplement with organic components was introduced and fed mixed in the feed. Within two years, fewer problems were experienced with retained placenta, and the incidence of scouring calves generally was reduced. First-service conception in the herd improved, with 85 percent or more

**Table 4. Liver biopsy mineral levels for cows supplemented with different mineral programs (ppm).**

| Item         | Control             | Inorganic           | Organic             | SEM <sup>a</sup> | P value <sup>b,c</sup> |
|--------------|---------------------|---------------------|---------------------|------------------|------------------------|
| Calcium 1    | 175.50              | 191.00              | 171.33              | 8.20             | 0.25                   |
| Calcium 2    | 250.83              | 213.29              | 258.67              | 31.14            | 0.57                   |
| Calcium Δ    | 75.33               | 22.29               | 87.33               | 30.14            | 0.31                   |
| Copper 1     | 59.67               | 81.86               | 80.17               | 14.73            | 0.55                   |
| Copper 2     | 29.83 <sup>a</sup>  | 209.42 <sup>b</sup> | 243.67 <sup>b</sup> | 30.44            | 0.01                   |
| Copper Δ     | -29.88 <sup>a</sup> | 127.57 <sup>b</sup> | 163.50 <sup>b</sup> | 28.63            | 0.01                   |
| Iron 1       | 396.17              | 690.57              | 346.00              | 228.23           | 0.55                   |
| Iron 2       | 306.67              | 279.86              | 331.67              | 31.21            | 0.54                   |
| Iron Δ       | -89.50              | -410.71             | -14.33              | 224.31           | 0.45                   |
| Magnesium 1  | 496.67              | 495.71              | 492.17              | 16.43            | 0.98                   |
| Magnesium 2  | 517.00              | 501.71              | 500.83              | 19.49            | 0.83                   |
| Magnesium Δ  | 20.33               | 6.00                | 8.67                | 22.48            | 0.90                   |
| Manganese 1  | 9.07                | 8.87                | 9.27                | 0.39             | 0.79                   |
| Manganese 2  | 9.68                | 9.06                | 9.70                | 0.50             | 0.61                   |
| Manganese Δ  | 0.62                | 0.19                | 0.43                | 0.58             | 0.88                   |
| Molybdenum 1 | 2.78                | 3.14                | 2.52                | 0.29             | 0.37                   |
| Molybdenum 2 | 2.84                | 2.92                | 2.79                | 0.18             | 0.88                   |
| Molybdenum Δ | 0.06                | -0.23               | 0.26                | 0.33             | 0.62                   |
| Phosphorus 1 | 10400               | 10518               | 10585               | 279.11           | 0.90                   |
| Phosphorus 2 | 10783               | 10462               | 10866               | 331.55           | 0.68                   |
| Phosphorus Δ | 383.33              | -55.71              | 281.67              | 338.15           | 0.65                   |
| Potassium 1  | 8160                | 7865                | 7871                | 307.46           | 0.77                   |
| Potassium 2  | 7360                | 7121                | 7271                | 467.57           | 0.94                   |
| Potassium Δ  | -800.00             | -744.29             | -600.00             | 454.61           | 0.96                   |
| Sodium 1     | 3860                | 4137                | 3891                | 289.68           | 0.77                   |
| Sodium 2     | 4655                | 4640                | 4688                | 467.24           | 1.00                   |
| Sodium Δ     | 795.00              | 502.86              | 796.67              | 505.38           | 0.90                   |
| Sulfur 1     | 7023                | 7197                | 7145                | 108.04           | 0.55                   |
| Sulfur 2     | 7056                | 7140                | 7203                | 173.23           | 0.86                   |
| Sulfur Δ     | 33.33               | -57.14              | 58.33               | 128.06           | 0.81                   |
| Zinc 1       | 79.17               | 86.86               | 85.67               | 4.59             | 0.50                   |
| Zinc 2       | 81.83               | 93.71               | 102.83              | 10.55            | 0.44                   |
| Zinc Δ       | 2.67                | 6.86                | 17.17               | 9.10             | 0.57                   |

1 indicates 1st liver biopsy collection May 5, 2006.

2 indicates 2nd liver biopsy collection Oct.26, 2006.

Δ Change in mineral status.

<sup>a</sup> Standard error of the mean, n = 6 observations per treatment.

<sup>b,c</sup> Means within rows having different superscripts differ  $P < 0.05$ .

calves born in the first 21 days of the calving season . We cannot specifically attribute the improvements to mineral nutrition without comparative research, but the indications are strong that a solid mineral program supports general good health and productivity.

## Conclusions

Mineral nutrition research is difficult at best, with subtle changes in animals and long-term response. The data suggests that stores of several minerals in this herd were adequate to cover the depletion phase with the possible exception of copper. While we did not observe differences in animal performance, one should be careful not to draw conclusions that mineral supplementation is not required because feeding programs, water and mineral stores can differ widely from site to site. Longer term studies evaluating herd health and mineral status under different production scenarios would be of interest but require significant resources. Consistent, high-quality mineral nutrition supports healthy animals with nutrients supplied by grazing, stored feeds, water or supplementation.

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# Effects of corn condensed distillers solubles supplementation on dry-matter intake, performance, rate and site of digestion, and ruminal fermentation in steers fed moderate-quality forages

L.R. Coupe<sup>1</sup>, G.P. Lardy<sup>1</sup>, T.C. Gilbery<sup>1</sup>, A.M. Meyer<sup>1</sup>, J.L. Leupp<sup>1</sup>, M.L. Bauer<sup>1</sup> and J.S. Caton<sup>1</sup>

*The objectives of this study were to evaluate the effects of amount and feeding method of corn condensed distillers solubles (CCDS) supplementation on dry-matter intake (DMI), site of digestion and ruminal fermentation in cannulated steers when fed moderate-quality forages. Corn condensed distillers solubles supplementation increases total DM and organic-matter (OM) intake as well as crude protein (CP) digestion but has minimal effects on fiber utilization and microbial efficiency in steers fed moderate-quality forages.*

## Summary

Five ruminally and duodenally cannulated steers ( $1,664 \pm 149.9$  pounds initial body weight [BW]) were used in a 5 x 5 Latin square to evaluate the effects of corn condensed distillers solubles (CCDS; 20.4 percent CP, 15.6 percent fat, 1.2 percent phosphorus, 1.2 percent sulfur; DM basis) supplementation on intake, site of digestion and ruminal fermentation when fed moderate-quality forage. Steers were offered ad libitum forage (8.2 percent CP, 73.6 percent neutral detergent fiber [NDF], 47.6 percent acid detergent fiber [ADF], DM basis); which was a mixture of 40 percent mature bluestem hay and 60 percent mixed grass alfalfa hay. Steers were penned individually during each seven-day adaptation period then placed in individual metabolism stalls during each seven-day collection period.

Treatments were arranged in a 2 x 2 + 1 factorial design; main effects were CCDS feeding method (mixed vs. fed separately) and level of CCDS (0.2 percent vs. 0.4 percent BW). The resulting five treatments were a negative control (no supplement), 0.2 percent BW CCDS mixed with the forage, 0.4 percent BW CCDS mixed with the forage, 0.2 percent BW

CCDS fed separately and 0.4 percent BW CCDS (DM basis) fed separately.

Supplementation with CCDS increased (pounds/day [lb/d];  $P = 0.04$ ) total DM and OM intake compared with the control. Steers fed 0.4 percent BW CCDS had increased (lb/d;  $P = 0.04$ ) total DM and OM intake compared with steers fed 0.2 percent BW CCDS. Total tract OM digestion increased ( $P = 0.01$ ) in steers fed 0.4 percent BW CCDS compared with 0.2 percent BW CCDS. Apparent and true ruminal CP digestion was increased ( $P = 0.05$ ) in supplemented steers and those fed 0.4 percent BW CCDS. Control steers had increased ( $P = 0.03$ ) total tract NDF and ADF digestion compared with supplemented steers. Steers fed CCDS separately had increased ( $P < 0.03$ ) total tract NDF and ADF digestion compared with steers fed mixed diets. Steers fed 0.4 percent BW CCDS had decreased ( $P = 0.04$ ) ruminal pH compared with steers fed 0.2 percent BW CCDS.

No treatment effects were observed for ruminal fill, fluid dilution rate or microbial efficiency ( $P \geq 0.17$ ). Results of this study suggest that CCDS supplementation increases total DM and OM intake as well as CP digestion but has minimal effects on fiber utilization and microbial efficiency in steers fed moderate-quality forages.

<sup>1</sup>Department of Animal Sciences, North Dakota State University, Fargo, N.D.

## Introduction

The ethanol industry is expanding throughout the Midwest; consequently, producers have the option to utilize resulting byproducts (RFA, 2008). Corn condensed distillers solubles (CCDS) are becoming more accepted as a protein supplement. Corn condensed distillers solubles are relatively high in CP and fat, which makes this product appealing for supplementing beef cows (Coupe et al., 2008).

Corn condensed distillers solubles are high in both protein and fat (15 percent to 25 percent CP and 4 percent to 22 percent fat, DM basis; Gilbery et al., 2006; Da Cruz et al., 2005). Gilbery et al. (2006) reported two studies that used CCDS as a supplement for low-quality forages and gave conflicting results. In the first study, forage DMI was not affected by increasing CCDS concentration when CCDS was fed separately from forage. In addition, total tract ADF and NDF digestibilities were not affected by increasing dietary CCDS. However, in a second study, forage DMI increased, with the greatest DMI observed when 10 percent CCDS was mixed with forage. The study also found a linear increase in ADF and NDF ruminal digestion when increasing CCDS was mixed with forage. One explanation for the differences between the studies could be that feeding CCDS and forage together results in improved synchrony and release of nutrients (Gilbery et al., 2006). However, more research is needed to better understand the differences in DMI and digestibility that occur when CCDS is fed mixed with or separately from forage.

## Materials and Methods

**Animals and Diet.** Five ruminally and duodenally cannulated Holstein steers were used in a 5 x 5 Latin square. Steers were offered ad libitum amount of a basal diet consisting of a mixture of 40 percent mature bluestem hay and 60 percent chopped mixed grass alfalfa hay (Table 1). Treatments consisted of a negative control (CON, no supplement), 0.2 percent BW CCDS mixed with the forage (DM basis), 0.4 percent BW CCDS mixed with the forage, 0.2 percent BW CCDS supplement fed separately and 0.4 percent BW CCDS fed separately. Mixed rations consisted of 1:0.55 forage to CCDS for the 0.2 percent mixed diet and 1:1.1 for the 0.4 percent mixed diet (as-fed basis). Steers fed CCDS separately were given one hour to consume the CCDS after which any remaining CCDS was dosed intra-ruminally. Orthogonal contrasts were used to separate means and included control vs. supplemented treatments, mixed diets vs. CCDS fed separately, 0.4 percent CCDS vs. 0.2 percent CCDS and the interaction of method of feeding x concentration of CCDS.

**Table 1. Analyzed nutrient content of forage and corn condensed distillers solubles (CCDS).**

| Item  | Forage <sup>1</sup> | CCDS <sup>2</sup> |
|-------|---------------------|-------------------|
| DM, % | 87.7                | 33.6              |
|       | --- %, DM Basis --- |                   |
| Fat   | ND <sup>3</sup>     | 15.6              |
| Ash   | 6.5                 | 6.9               |
| CP    | 8.2                 | 20.4              |
| NDF   | 73.6                | ND                |
| ADF   | 47.6                | ND                |
| Ca    | 0.6                 | 0.1               |
| P     | 0.1                 | 1.2               |
| S     | ND                  | 1.2               |

<sup>1</sup>Forage consisted of 40% mature bluestem hay and 60% mixed grass alfalfa hay.

<sup>2</sup>CCDS = corn condensed distillers solubles.

<sup>3</sup>ND = not determined.

## Results

The study found a tendency ( $P = 0.08$ ) for a feeding method x CCDS concentration interaction for forage DMI (lb/d, Table 2). Forage DMI increased when increasing CCDS was mixed with the forage but decreased when CCDS was fed separately. By design, CCDS DMI increased ( $P < 0.01$ ) in supplemented steers compared with control and in steers fed high versus low treatments. However, an increase ( $P < 0.01$ ) in CCDS DMI occurred in steers fed CCDS separately compared with those fed mixed diets. Total DMI (lb/d) was increased ( $P = 0.04$ ) in supplemented steers compared with control steers. Total DMI (lb/d) was greater ( $P = 0.04$ ) in steers fed 0.4 percent BW CCDS than those steers fed 0.2 percent BW CCDS. However, no differences ( $P > 0.35$ ) were noted when forage or total intake was expressed as a percentage of BW.

Concentrations of ammonia ( $\text{NH}_3$ ) ( $3.89 \pm 0.72$  millimolar [mM]) and total volatile fatty acid (VFA) ( $71.3 \pm 6.2$  mM) were not affected ( $P > 0.17$ ) by treatment (Table 3). Ruminal pH ( $6.74 \pm 0.09$ ) was decreased ( $P = 0.04$ ) in steers fed 0.4 percent BW CCDS compared with steers fed 0.2 percent BW CCDS, whereas ruminal pH was not different between the control and supplemented treatments ( $P = 0.12$ ). Molar proportion of acetate was reduced ( $P = 0.02$ ) in supplemented steers compared with the control, whereas molar proportion of butyrate was increased in supplemented steers ( $P < 0.01$ ) and those fed 0.4 percent BW CCDS ( $P = 0.01$ ). Molar proportion of propionate tended to be greater in supplemented steers ( $P = 0.06$ ), steers fed CCDS separately ( $P = 0.05$ ) and steers fed 0.4 percent BW CCDS ( $P = 0.07$ ). The acetate to propionate ratio was decreased ( $P < 0.01$ ) in supplemented steers and was increased ( $P < 0.01$ ) in steers fed mixed diets.

Apparent ruminal, true ruminal and intestinal digestion of OM were not affected ( $P > 0.22$ ) by treatments (Table 4). Total tract digestion was increased ( $P = 0.01$ ) in steers fed 0.4 percent BW CCDS compared with steers fed 0.2 percent BW CCDS. Apparent ruminal, true ruminal and total tract CP digestion increased ( $P < 0.01$ ) in supplemented steers compared with control-fed steers, whereas intestinal CP digestion was decreased ( $P < 0.01$ ) in supplemented steers. Steers fed 0.4 percent BW CCDS had increased apparent ruminal ( $P = 0.01$ ), true ruminal ( $P = 0.05$ ) and total tract ( $P < 0.01$ ) CP digestion compared with steers fed 0.2 percent BW CCDS. However, steers fed 0.4 percent BW CCDS had decreased ( $P = 0.04$ ) intestinal CP digestion.

Microbial efficiency was not affected ( $P = 0.21$ ) by treatments and averaged  $14.8 \pm 5.7$  grams of microbial nitrogen per kilogram (N/kg) of OM truly fermented. Total tract digestion of NDF and ADF was decreased ( $P < 0.03$ ) with CCDS supplementation.

## Implications

Supplementation of CCDS increases forage DMI. Supplementation of CCDS can provide added protein and energy to moderate-quality forages to maintain acceptable production levels. Supplementation of CCDS increases digestion and utilization of CP but has minimal effects on fiber digestion and microbial efficiency.

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**Table 2. Effects of corn condensed distillers solubles (CCDS) supplementation on DMI, ruminal fill and fluid dilution rate in steers consuming a forage-based diet.**

| Item                     | Treatment <sup>1</sup> |       |          |          |          | SEM <sup>3</sup> | P-Value <sup>4</sup> | Contrast <sup>2</sup> |             |              |            |
|--------------------------|------------------------|-------|----------|----------|----------|------------------|----------------------|-----------------------|-------------|--------------|------------|
|                          | CON                    | MIX   | 0.2% MIX | 0.2% SEP | 0.4% SEP |                  |                      | CON vs. SUP           | MIX vs. SEP | HIGH vs. LOW | METH x LEV |
| Forage DM intake         |                        |       |          |          |          |                  |                      |                       |             |              |            |
| lb/d                     | 14.9                   | 13.2  | 14.2     | 13.8     | 11.1     | 0.66             | 0.130                | 0.123                 | 0.232       | 0.381        | 0.081      |
| % of BW                  | 0.80                   | 0.77  | 0.95     | 0.70     | 0.57     | 0.14             | 0.349                | 0.689                 | 0.104       | 0.847        | 0.242      |
| CCDS DM intake, lb/d     | 0.00                   | 2.05  | 5.25     | 3.55     | 6.92     | 0.44             | <0.001               | <0.001                | 0.003       | <0.001       | 0.828      |
| Total intake             |                        |       |          |          |          |                  |                      |                       |             |              |            |
| lb/d                     | 14.9                   | 15.3  | 19.4     | 17.4     | 18.0     | 1.68             | 0.043                | 0.041                 | 0.736       | 0.038        | 0.111      |
| % of BW                  | 0.81                   | 0.89  | 1.31     | 0.93     | 0.98     | 0.20             | 0.422                | 0.312                 | 0.469       | 0.238        | 0.347      |
| Ruminal DM fill, % of BW | 16.36                  | 11.25 | 11.96    | 9.29     | 9.98     | 2.73             | 0.315                | 0.052                 | 0.431       | 0.778        | 0.997      |
| Fluid dilution rate, %/h | 9.17                   | 12.04 | 12.01    | 9.51     | 11.42    | 1.18             | 0.173                | 0.089                 | 0.148       | 0.372        | 0.361      |

<sup>1</sup>CON = forage only, 0.2%; MIX = forage mixed with 0.2% BW CCDS, 0.4%; MIX = forage mixed with 0.4% BW CCDS, 0.2%; SEP = forage with 0.2% BW CCDS fed separately, 0.4%; MIX = forage with 0.4% BW CCDS fed separately.

<sup>2</sup>CON vs. SUP = control treatment vs. all supplemented treatments; MIX vs. SEP = forage and CCDS mixed vs. forage and CCDS fed separately; HIGH vs. LOW = 0.4% BW CCDS vs. 0.2% BW CCDS; METH x LEV = method of feeding (mixed or fed separately) by level interaction.

<sup>3</sup>n = 5 observations.

<sup>4</sup>Probability value for the F-test of overall treatment.

**Table 3. Effects of corn condensed distillers solubles (CCDS) supplementation on ruminal pH, NH<sub>4</sub> concentration and VFA concentration in steers consuming a forage-based diet.**

| Item                             | Treatment <sup>1</sup> |          |          |          |          | SEM <sup>3</sup> | P-value <sup>4</sup> |        |            | Contrast <sup>2</sup> |             |              |            |
|----------------------------------|------------------------|----------|----------|----------|----------|------------------|----------------------|--------|------------|-----------------------|-------------|--------------|------------|
|                                  | CON                    | 0.2% MIX | 0.4% MIX | 0.2% SEP | 0.4% SEP |                  | Trt                  | Time   | Trt x Time | CON vs. SUP           | MIX vs. SEP | HIGH vs. LOW | METH x LEV |
| pH                               | 6.80                   | 6.77     | 6.64     | 6.77     | 6.72     | 0.09             | 0.092                | 0.010  | 0.168      | 0.120                 | 0.407       | 0.042        | 0.343      |
| NH <sub>3</sub> , mM             | 3.08                   | 4.66     | 4.20     | 3.27     | 4.26     | 0.72             | 0.173                | <0.001 | 0.019      | 0.093                 | 0.611       | 0.207        | 0.172      |
| Total VFA, mol/100mol            | 73.2                   | 70.4     | 75.5     | 69.7     | 67.7     | 6.18             | 0.231                | 0.017  | 0.047      | 0.388                 | 0.102       | 0.529        | 0.168      |
| Acetate                          | 57.7                   | 53.7     | 51.6     | 53.7     | 49.7     | 6.63             | 0.078                | <0.001 | 0.947      | 0.016                 | 0.602       | 0.117        | 0.590      |
| Propionate                       | 12.7                   | 13.0     | 14.0     | 14.2     | 15.9     | 1.93             | 0.048                | <0.001 | <0.001     | 0.062                 | 0.048       | 0.070        | 0.666      |
| Butyrate                         | 4.1                    | 7.0      | 9.0      | 7.0      | 8.6      | 0.97             | <0.001               | <0.001 | 0.002      | <0.001                | 0.819       | 0.007        | 0.733      |
| Acetate: Propionate <sup>5</sup> | 4.6                    | 4.1      | 3.8      | 3.8      | 3.3      | 0.12             | <0.001               | <0.001 | 0.006      | <0.001                | 0.003       | 0.001        | 0.495      |

<sup>1</sup>CON = forage only, 0.2%; MIX = forage mixed with 0.2% BW CCDS, 0.4%; MIX = forage mixed with 0.4% BW CCDS, 0.2%; SEP = forage with 0.2% BW CCDS fed separately, 0.4%; MIX = forage with 0.4% BW CCDS fed separately.

<sup>2</sup>CON vs. SUP = control treatment vs. all supplemented treatments; MIX vs. SEP = forage and CCDS mixed vs. forage and CCDS fed separately; HIGH vs. LOW = 0.4% BW CCDS vs. 0.2% BW CCDS; METH x LEV = method of feeding (mixed or fed separately) by level interaction.

<sup>3</sup>n = 5 observations.

<sup>4</sup>Probability value for the F-test of overall treatment.

<sup>5</sup>Ratio of acetate to propionate.

**Table 4. Effects of corn condensed distillers solubles (CCDS) supplementation on OM, CP, NDF and ADF digestion in steers consuming a forage-based diet.**

| Item                              | Treatment <sup>1</sup> |          |          |          |          | SEM <sup>3</sup> | P-value <sup>4</sup> | Contrast <sup>2</sup> |             |              |            |
|-----------------------------------|------------------------|----------|----------|----------|----------|------------------|----------------------|-----------------------|-------------|--------------|------------|
|                                   | CON                    | 0.2% MIX | 0.4% MIX | 0.2% SEP | 0.4% SEP |                  |                      | CON vs. SUP           | MIX vs. SEP | HIGH vs. LOW | METH x LEV |
| OMI, lb/d                         | 13.9                   | 14.2     | 18.0     | 16.2     | 16.8     | 1.57             | 0.046                | 0.044                 | 0.643       | 0.040        | 0.117      |
| OM digestion, % of intake         |                        |          |          |          |          |                  |                      |                       |             |              |            |
| Apparent ruminal                  | 40.6                   | 39.2     | 45.1     | 40.6     | 49.9     | 8.00             | 0.259                | 0.499                 | 0.420       | 0.068        | 0.676      |
| True ruminal                      | 54.0                   | 54.5     | 60.8     | 55.9     | 63.1     | 6.3              | 0.223                | 0.250                 | 0.586       | 0.059        | 0.890      |
| Intestinal                        | 10.9                   | 12.8     | 13.1     | 13.6     | 14.4     | 3.0              | 0.773                | 0.277                 | 0.597       | 0.786        | 0.913      |
| Total tract                       | 49.9                   | 52.0     | 57.3     | 50.5     | 64.3     | 5.9              | 0.036                | 0.110                 | 0.402       | 0.011        | 0.209      |
| CP digestion, % intake            |                        |          |          |          |          |                  |                      |                       |             |              |            |
| Apparent ruminal                  | -54.1                  | -16.0    | -0.3     | -27.9    | 3.5      | 1.7              | 0.003                | <0.001                | 0.615       | 0.014        | 0.340      |
| True ruminal                      | 26.0                   | 43.9     | 50.54    | 37.4     | 50.5     | 9.0              | 0.019                | 0.004                 | 0.476       | 0.052        | 0.486      |
| Intestinal                        | 99.8                   | 73.8     | 67.8     | 83.5     | 63.5     | 12.7             | 0.004                | 0.001                 | 0.635       | 0.036        | 0.225      |
| Total tract                       | 43.8                   | 57.8     | 66.7     | 51.8     | 67.0     | 5.7              | <0.001               | <0.001                | 0.363       | 0.002        | 0.323      |
| Microbial efficiency <sup>5</sup> | 14.4                   | 12.6     | 14.4     | 13.9     | 11.2     | 2.8              | 0.214                | 0.304                 | 0.649       | 0.387        | 0.066      |
| Digestion, % intake               |                        |          |          |          |          |                  |                      |                       |             |              |            |
| Total tract NDF                   | 51.1                   | 37.7     | 27.6     | 39.6     | 44.2     | 7.4              | 0.011                | 0.006                 | 0.031       | 0.479        | 0.075      |
| Total tract ADF                   | 48.6                   | 36.6     | 27.1     | 39.3     | 45.5     | 7.4              | 0.022                | 0.026                 | 0.023       | 0.694        | 0.078      |

<sup>1</sup>CON = forage only, 0.2%; MIX = forage mixed with 0.2% BW CCDS, 0.4%; MIX = forage mixed with 0.4% BW CCDS, 0.2%; SEP = forage with 0.2% BW CCDS fed separately, 0.4%; MIX = forage with 0.4% BW CCDS fed separately.

<sup>2</sup>CON vs. SUP = control treatment vs. all supplemented treatments; MIX vs. SEP = forage and CCDS mixed vs. forage and CCDS fed separately; HIGH vs. LOW = 0.4% BW CCDS vs. 0.2% BW CCDS; METH x LEV = method of feeding (mixed or fed separately) by level interaction.

<sup>3</sup>n = 5 observations.

<sup>4</sup>Probability value for the F-test of overall treatment.

<sup>5</sup>Grams of microbial N per kilogram of OM truly fermented.

# Influence of thiamin supplementation on hydrogen sulfide gas concentrations in ruminants fed high-sulfur diets\*

B.W. Neville<sup>1</sup>, C.S. Schauer<sup>2</sup> and G.P. Lardy<sup>1</sup>

*The objective of this research was to evaluate the influence of thiamin supplementation on hydrogen sulfide gas concentration and ruminal pH in lambs fed high-sulfur diets. Moderate levels of thiamin supplementation seem to decrease hydrogen sulfide concentrations. Our data suggests that changes in ruminal hydrogen sulfide concentration cannot be attributed solely to ruminal pH and are likely affected by multiple factors that interact within the ruminal environment and in the animal.*

## Summary

The objective of this study was to evaluate the effect of increasing levels of thiamin supplementation on ruminal gas cap hydrogen sulfide (H<sub>2</sub>S) concentration and pH in lambs. Twenty crossbred lambs (84.5 ± 7 pounds) were adapted in 28 days to a finishing diet consisting of (dry-matter [DM] basis) 60 percent dried distillers grains with solubles, 21.4 percent corn, 15 percent alfalfa hay and 3.6 percent supplement. Treatment diets differed in the amount of supplemental thiamin supplied; diets were formulated to provide: 1) CON (no supplemental thiamin), 2) LOW (50 milligrams per head per day [mg·hd<sup>-1</sup>·d<sup>-1</sup>] thiamin), 3) MED (100 mg·hd<sup>-1</sup>·d<sup>-1</sup> thiamin), 4) HIGH (150 mg·hd<sup>-1</sup>·d<sup>-1</sup> thiamin) or 5) HIGH+S (150 mg·hd<sup>-1</sup>·d<sup>-1</sup> thiamin with dietary sulfur [S] increased from 0.71 percent to 0.87 percent (DM basis) with the addition of dilute sulfuric acid to dried distillers grains with solubles [DDGS]). Thiamin supplementation was based on an estimated daily dry-matter intake (DMI) of 3 lb·hd<sup>-1</sup>·d<sup>-1</sup>.

Hydrogen sulfide and rumen fluid pH were collected via rumen puncture on day minus 6, minus 3, 0, 3, 7, 10, 14, 17, 21, 24, 28 and 31. No differences in H<sub>2</sub>S concentration (P > 0.10) among treatments were apparent until day 10, at which point lambs fed LOW had lower H<sub>2</sub>S concentrations than all other treatments. Lambs fed

HIGH had the greatest concentrations of H<sub>2</sub>S on day 31 (7,700 parts per million [ppm] H<sub>2</sub>S; P < 0.009). Ruminal pH for lambs fed CON and MED were not different from day 0 throughout sampling (P > 0.18). Ruminal pH of LOW, HIGH and HIGH+S groups decreased (P < 0.03) through time. Thiamin appears to influence ruminal H<sub>2</sub>S concentrations, although the mechanism by which this occurred remains unknown. Changes in H<sub>2</sub>S concentration cannot be attributed solely to ruminal pH and likely are affected by multiple factors that interact within the ruminal environment and in the animal.

## Introduction

One of the challenges with use of ethanol co-products is the potential for high dietary S levels. High S diets can cause polioencephalomalacia (PEM) in ruminants. Inclusion of large percentages of co-product feeds, such as dried distillers grains with solubles (DDGS), in finishing rations has been avoided, in part, due to problems with PEM as well as concerns about optimal animal performance and carcass characteristics. Thiamin supplementation is one proposed method of reducing or preventing PEM in ruminant animals. The efficacy of thiamin supplementation in preventing PEM likely is impacted by the mechanisms by which PEM is caused (for example, long-term thiamin deficiency or high hydrogen sulfide gas concentration). Further, the

\*Partial support for this research and dried distillers grains with solubles were provided by Poet Nutrition, Sioux Falls, S.D. Disclaimer: Any opinions, findings, conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of Poet Nutrition.

<sup>1</sup>North Dakota State University, Department of Animal Sciences, Fargo, N.D.

<sup>2</sup>Hettinger Research Extension Center, Hettinger, N.D.

effect and dose of thiamin necessary to prevent such cases of PEM requires more investigation. Hydrogen sulfide gas, as previously mentioned, has been implicated as a cause of PEM in ruminants. Both high-sulfur feed (Niles et al., 2002) and water (Loneragan et al., 2005) sources can cause increases in H<sub>2</sub>S production. No published literature that evaluates the effect of dietary thiamin concentrations on ruminal H<sub>2</sub>S gas concentration is available. Therefore, our objective was to evaluate the effect of increasing level of thiamin supplementation on ruminal gas cap H<sub>2</sub>S concentration and ruminal pH in lambs being adapted to a finishing diet containing 60 percent DDGS.

## Procedures

Twenty western white-face wether lambs (84.5 ± 7 pounds) were sampled during the adaptation period (receiving ration to a final finishing ration). Adaptation was accomplished by increasing the amount of concentrate on a weekly basis; adaptation diets are outlined in (Table 1). The final finishing diet was balanced to contain 60 percent DDGS (DM basis; Table 2). Treatment diets differed in the amount of supplemental thiamin supplied; diets were formulated to provide: 1) CON (no supplemental thiamin), 2) LOW (50 mg·hd<sup>-1</sup>·d<sup>-1</sup> thiamin), 3) MED (100 mg·hd<sup>-1</sup>·d<sup>-1</sup> thiamin), 4) HIGH (150 mg·hd<sup>-1</sup>·d<sup>-1</sup> thiamin) or 5) HIGH+S (150 mg·hd<sup>-1</sup>·d<sup>-1</sup> thiamin with dietary S increased from 0.71 percent to 0.87 percent [DM basis] with the addition of dilute sulfuric acid to DDGS). Thiamin supplementation was based on an estimated daily DMI of 3 lb·hd<sup>-1</sup>·d<sup>-1</sup>. Feed was offered daily

on an ad libitum basis with refusals collected and weighed weekly.

Sampling for ruminal H<sub>2</sub>S was conducted on 12 occasions beginning six days prior to initiation of treatment diets. Gas cap samples from these lambs were collected on day minus 6, minus 3, 0, 3, 7, 10, 14, 17, 21, 24, 28 and 31 of the feeding period. Hydrogen sulfide gas was measured on H<sub>2</sub>S detector tubes (GASTEC®, Kanagawa, Japan). Ruminal fluid also was collected at the same time for determination of rumen fluid pH.

## Results and Discussion

The influence of hydrogen sulfide gas on incidence of PEM in ruminants could be impacted by the way H<sub>2</sub>S concentration changes during adaptation to finishing rations. In the present study, no differences in H<sub>2</sub>S concentration among treatments (P > 0.10; Table 3) were apparent until day 10, at which point lambs fed LOW had lower H<sub>2</sub>S concentrations than all other treatments. At this point in adaptation, the amount of roughage included in the diet had not changed

**Table 1. Adaptation diets fed to lambs (% DM basis).**

|                         | Arrival<br>day -6 | Step 1<br>day 0 | Step 2<br>day 7 | Step 3<br>day 14 | Step 4<br>day 21 | Step 5<br>day 28 |
|-------------------------|-------------------|-----------------|-----------------|------------------|------------------|------------------|
| <i>Ingredient, %</i>    |                   |                 |                 |                  |                  |                  |
| Alfalfa Hay             | 46.00             | 46.00           | 46.00           | 35.00            | 25.00            | 15.00            |
| Corn                    | 50.38             | 35.88           | 21.38           | 21.38            | 21.38            | 21.38            |
| DDGS                    | 0.00              | 14.50           | 29.00           | 40.00            | 50.00            | 60.00            |
| Supplement <sup>1</sup> | 3.62              | 3.62            | 3.62            | 3.62             | 3.62             | 3.62             |

<sup>1</sup>Supplement contained: (% of total diet DM) 0.5% ammonium chloride, 2.25% limestone, 0.085% lasalocid, 0.78% trace mineral and 0.002% copper sulfate, and were formulated to provide one of four levels of thiamin (0, 50, 100 or 150 mg·hd<sup>-1</sup>·d<sup>-1</sup>).

**Table 2. Ingredient and nutritional composition (DM basis) of final finishing rations fed to lambs.**

| Item                        | Treatments <sup>1</sup> |       |       |       |        |
|-----------------------------|-------------------------|-------|-------|-------|--------|
|                             | CON                     | LOW   | MED   | HIGH  | HIGH+S |
| <i>Ingredient, %</i>        |                         |       |       |       |        |
| Alfalfa Hay                 | 15.00                   | 15.00 | 15.00 | 15.00 | 15.00  |
| Corn                        | 21.38                   | 21.38 | 21.38 | 21.38 | 21.38  |
| DDGS                        | 60.00                   | 60.00 | 60.00 | 60.00 | 60.00  |
| Supplement <sup>2</sup>     | 3.62                    | 3.62  | 3.62  | 3.62  | 3.62   |
| <i>Nutrient<sup>3</sup></i> |                         |       |       |       |        |
| CP, %                       | 23.3                    | 23.6  | 23.4  | 22.7  | 23.5   |
| ADF, %                      | 10.8                    | 11.0  | 11.6  | 11.6  | 11.3   |
| S, %                        | 0.76                    | 0.69  | 0.75  | 0.71  | 0.87   |
| Ca, %                       | 1.55                    | 1.42  | 1.65  | 1.66  | 1.77   |
| P, %                        | 0.79                    | 0.81  | 0.92  | 0.91  | 0.87   |
| Thiamin <sup>4</sup>        | 0                       | 50    | 100   | 150   | 150    |

<sup>1</sup> Treatments: CON (no supplemental thiamin), LOW (50 mg·hd<sup>-1</sup>·d<sup>-1</sup> thiamin), MED (100 mg·hd<sup>-1</sup>·d<sup>-1</sup> thiamin), HIGH (150 mg·hd<sup>-1</sup>·d<sup>-1</sup> thiamin) and HIGH+S (150 mg·hd<sup>-1</sup>·d<sup>-1</sup> thiamin with 0.87% S).

<sup>2</sup> Supplement (% total diet): 0.5% ammonium chloride, 2.25% limestone, 0.085% lasalocid, 0.78% sheep mineral 12 (Hubbard Feeds, Mankato, Minn.), 0.002% copper sulfate and 0, 0.004, 0.007 or 0.11% thiamin mononitrate.

<sup>3</sup> Laboratory analysis of nutrient concentration.

<sup>4</sup> Formulated level (ppm), thiamin inclusion in diet calculated based on an estimated DMI of 3.0 lb·hd<sup>-1</sup>·d<sup>-1</sup>.

**Table 3. Influence of thiamin and sulfur level on hydrogen sulfide concentration in lambs fed a 60% DDGS-based finishing diet.**

|  | Treatment <sup>1,2</sup> |                      |                        |                       |                       |
|--|--------------------------|----------------------|------------------------|-----------------------|-----------------------|
|  | CON                      | LOW                  | MED                    | HIGH                  | HIGH+S                |
|  | 0.0                      | 0.0                  | 0.0                    | 190.6                 | 75.0                  |
|  | 66.7                     | 0.0                  | 112.5                  | 25.0                  | 28.1                  |
|  | 71.5                     | 0.0                  | 146.9                  | 71.9                  | 93.8                  |
|  | 531.3                    | 375.0                | 310.5                  | 737.5                 | 475.0                 |
|  | 778.1                    | 575.0                | 759.4                  | 1,237.5               | 1,350.0               |
|  | 2,200.0 <sup>a</sup>     | 887.5 <sup>b</sup>   | 2,200.0 <sup>a</sup>   | 2,453.1 <sup>a</sup>  | 2,378.1 <sup>a</sup>  |
|  | 2,390.6 <sup>a</sup>     | 1,087.5 <sup>b</sup> | 1,875.0 <sup>a</sup>   | 1,906.3 <sup>a</sup>  | 2,015.6 <sup>a</sup>  |
|  | 2,852.6 <sup>a</sup>     | 1,418.8 <sup>b</sup> | 2,609.4 <sup>a</sup>   | 2,406.3 <sup>ab</sup> | 2,406.3 <sup>ab</sup> |
|  | 3,312.5 <sup>a</sup>     | 1,531.3 <sup>c</sup> | 2,328.1 <sup>abc</sup> | 1,958.2 <sup>bc</sup> | 3,140.6 <sup>ab</sup> |
|  | 2,062.5 <sup>a</sup>     | 3,287.5 <sup>b</sup> | 3,275.0 <sup>b</sup>   | 4,991.6 <sup>c</sup>  | 3,046.9 <sup>ab</sup> |
|  | 4,687.5 <sup>a</sup>     | 2,662.5 <sup>b</sup> | 2,906.3 <sup>b</sup>   | 6,657.8 <sup>c</sup>  | 4,390.6 <sup>a</sup>  |
|  | 5,687.5 <sup>a</sup>     | 2,650.0 <sup>b</sup> | 3,843.8 <sup>c</sup>   | 7,701.3 <sup>d</sup>  | 4,859.4 <sup>ac</sup> |

<sup>1</sup> Treatments: CON (no supplemental thiamin), LOW (50 mg·hd<sup>-1</sup>·d<sup>-1</sup> thiamin), MED (100 mg·hd<sup>-1</sup>·d<sup>-1</sup> thiamin), HIGH (150 mg·hd<sup>-1</sup>·d<sup>-1</sup> thiamin) and HIGH+S (150 mg·hd<sup>-1</sup>·d<sup>-1</sup> thiamin with 0.87% S).

<sup>2</sup> When tube measurement was below 100 ppm, tube was considered to read 0.

<sup>abc</sup> Means with different superscripts within a row differ P < 0.10.

although the inclusion of DDGS had increased from 0 percent to 29 percent of dietary DM. Those lambs fed the HIGH treatment diet showed the most dramatic increases in ruminal H<sub>2</sub>S concentration; on day 21 of adaptation, dietary hay was decreased from 35 percent to 25 percent and DDGS increased from 40 percent to 50 percent of dietary DM. During the course of the next three days, ruminal H<sub>2</sub>S concentration increased by more than 3,000 ppm and within seven days had increased by 4,700 ppm H<sub>2</sub>S.

While the hydrogen sulfide concentrations in our lambs did not reach the levels in steers reported by Niles et al. (2002), our peak

concentrations were above those reported by Loneragan et al. (2005); both of these studies had steers with positive cases of PEM. These results indicate that the concentration of H<sub>2</sub>S required to cause symptoms of PEM may vary depending on species.

Of further interest is the way the H<sub>2</sub>S concentration in lambs fed HIGH+S changed during adaptation. Specifically, on days 7, 14 and 21, the concentration of H<sub>2</sub>S was greater in HIGH+S than HIGH; however, after three days of adaptation (days 10, 17, 24) the concentration of ruminal H<sub>2</sub>S from HIGH+S was lower or equal to that found in HIGH fed lambs.

Multiple factors influence the conversion of dietary S into H<sub>2</sub>S in

the rumen during adaptation. Among these are decreases in ruminal fluid pH, increases in the proportion of sulfur-reducing bacteria and increases in dietary S. In our study, ruminal pH did not differ among treatments (P = 0.13) at any time point (data not shown). Lambs fed CON and MED were not different from day 0 throughout sampling (P > 0.18). However, ruminal pH of LOW, HIGH and HIGH+S groups did decrease (P < 0.03) through time. Decreases in ruminal pH also may impact incidence of PEM by other means.

Our research suggests that thiamin may influence ruminal H<sub>2</sub>S concentrations, but we did not investigate the fate of the H<sub>2</sub>S. Further, our data suggests that changes in ruminal hydrogen sulfide concentration cannot be attributed solely to ruminal pH and likely are affected by multiple factors that interact within the ruminal environment and in the animal.

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# Effect of weaning and production management strategies on calf growth and carcass traits\*

M.M. Thompson<sup>1</sup>, C.S. Schauer<sup>1</sup>, V.L. Anderson<sup>2</sup>, B.R. Ilse<sup>2</sup>, J.C. Galbreath<sup>3</sup> and R.J. Maddock<sup>3</sup>

*This study investigated the effects of weaning date (early vs. normal) and production system practices (natural vs. conventional) on calf growth and carcass traits in May-born Angus calves during the grow-finish period. Our research suggests that conventionally managed calves gained more weight in the background and finish periods than naturally managed calves, and early weaned calves may gain more slowly than normally weaned calves.*

## Summary

This study investigated the effects of weaning date (early vs. normal) and production system practices (natural vs. conventional) on calf growth and carcass traits in May-born Angus calves during the grow-finish period. One of four production management treatments (TRT) was assigned to 81 Angus steer and heifer calves at the NDSU Hettinger Research Extension Center: early wean-conventional production (EWC; 137 days old), early wean-natural production (EWN; 132 days old), normal wean-conventional production (NWC; 192 days old) and normal wean-natural production (NWN; 199 days old). After the background period (EW = 115 days and NW = 59 days), calves were shipped to the NDSU Carrington Research Extension Center for finishing.

Calves were fed to a common end weight (1,100 pounds) and back fat thickness (0.4 inch) prior to harvest. Calves were harvested and individual carcass measurements collected on two dates. The weaning date impacted weaning weights and background weight gain ( $P < 0.001$ ); however, background end weights were similar across TRT ( $P = 0.42$ ) after 115 days. At the end of the 133-day finish period, final weight, total gain and average daily gain (ADG) were different across TRT ( $P \leq 0.01$ ). Most carcass traits were similar at harvest ( $P > 0.05$ ) regardless of TRT, with the exception of hot carcass weights

( $P = 0.02$ ). Our research suggests that conventionally managed calves gained more weight in the background and finish periods than naturally managed calves, and early weaned calves may gain more slowly than normally weaned calves.

## Introduction

Most cow-calf producers in the northern Great Plains calve beef cows in the late winter-early spring months (February and March), guaranteeing ranch resources, time and labor will be readily available in the spring for annual crop planting and fieldwork needs. Conversely, some cattle producers have chosen to calve during the late spring months (May and June) to follow nature's traditional growth patterns for pasture grasses. With a later calving season, higher-quality grazing diets are provided for lactating brood cows and nursing calves, further maximizing milk production and calf growth. However, during drought when forage supplies become limited, the calf-weaning date is moved forward, sparing necessary forage resources for gestating and/or lactating beef cows.

The definition of early weaning varies; generally, calves weaned before 150 days of age are considered early weaned (Loy et al., 1999). Most research on early weaning has focused on late winter-early spring (February and March) calving cowherds (Schoonmaker et al., 2001; Story et al., 2000), with little research evaluating

<sup>1</sup> Hettinger Research Extension Center, North Dakota State University, Hettinger, ND 58639

<sup>2</sup> Carrington Research Extension Center, North Dakota State University, Carrington, ND 58421

<sup>3</sup> Department of Animal Sciences, North Dakota State University, Fargo, ND 58105

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early weaning outcomes on late spring-born (May and June) calves. In recent years, marketing opportunities have grown for “natural” beef, which are cattle raised without antibiotics and growth-promoting technologies such as ionophores and implants. Cattle producers question how “never, ever” natural production practices measure up to mainstream conventional production systems.

Furthermore, few studies have examined the consequences of late spring-born calves raised under natural production system practices. Our study objective was to investigate the effects of weaning date (early vs. normal) and production system practices (natural vs. conventional) on calf growth and carcass traits in May-born Angus calves during the grow-finish period. We hypothesized the early weaned calves raised under natural production practices would have more morbidity, resulting in reduced performance and lower carcass quality as compared with the other three production systems (early weaned-conventional, normal weaning-conventional and normal weaning-natural calves) studied.

## Materials and Methods

The NDSU Institute for Animal Care and Use Committee approved all protocols. The experiment was conducted at the NDSU Hettinger Research Extension Center’s feedlot in Hettinger, N.D., and the NDSU Carrington Research Extension Center’s feedlot in Carrington, N.D. Eighty-one Angus steer and heifer calves (average birth date = May 3 ± 2.12 days) from the NDSU Hettinger Research Extension Center’s cowherd were assigned to two weaning dates: early wean = Sept. 13 and Sept. 14, 2007, (EW), or normal wean = Nov. 15 and Nov. 16, 2007, (NW).

On respective weaning dates, EW and NW calves were hauled (five miles) to the feedlot after morning gathering and weighing in the pasture. Calves

assigned to the EW group averaged 422 pounds at weaning, while NW calves averaged 553 pounds at weaning. All calves were fed a receiving ration (total mixed ration) containing 27.6 percent barley silage, 7.4 percent protein supplement, 29.5 percent ground mixed hay, 29.8 percent whole barley, 2.7 percent deccox crumbles, 2.4 percent sodium bicarbonate and 0.6 percent calcium carbonate (dry-matter basis; 14.8 percent crude protein; 0.52 megacalories/pound of net energy for gain) for the first 17 days (EW) and 10 days (NW) after weaning.

On Oct. 2, 2007, (EW) and Nov. 27, 2007, (NW) calves were weighed following an overnight shrink, stratified by weight and sex, and allotted to one of 12 pens (six or seven calves/pen) for backgrounding (EW = 115 days; NW = 59 days). Pens were

assigned to one of four production management treatments (TRT; n = 3): early wean-conventional production (EWC), early wean-natural production (EWN), normal wean-conventional production (NWC) and normal wean-natural production (NWN). Calves receiving “natural” treatments (EWN and NWN) did not receive growth-promoting implants and were not fed ionophores. When natural fed calves were treated with antibiotics for illness, they were removed from their respective treatments. Calves were fed a 58:42 forage:concentrate diet during the growing period (14 percent crude protein; 0.52 megacalories/pound of net energy for gain growing diet; dry-matter basis; Table 1). The conventional protein supplement for the growing diet provided 225 milligrams/hd/d of Rumensin (Elanco Animal Health, Indianapolis, Ind.) and 0.5 mg/lb MGA (melengestrol acetate,

**Table 1. Dietary ingredient and nutrient concentration of calf growing and finishing diets.**

| Item                                      | Growing Diet | Finishing Diet |
|---|--------------|----------------|
| <i>Ingredient, % DM</i>                   |              |                |
| Barley silage                             | 27.8         | -              |
| Calcium carbonate                         | 0.60         | -              |
| Corn silage                               | -            | 13.3           |
| Deccox crumbles                           | 2.7          | -              |
| Growing supplement <sup>a,b</sup>         | 7.5          | -              |
| Finishing supplement <sup>c,d</sup>       | -            | 1.4            |
| Mixed hay, ground <sup>e</sup>            | 29.8         | -              |
| Rolled corn                               | -            | 45.0           |
| Sodium bicarbonate                        | 1.60         | -              |
| Wet distillers grain                      | -            | 35.0           |
| Wheat straw, chopped                      | -            | 5.30           |
| Whole barley                              | 30.0         | -              |
| <i>Nutrient concentration<sup>f</sup></i> |              |                |
| % DM                                      | 57.8         | 67.0           |
| CP, % DM                                  | 14.0         | 14.0           |
| NEg, Mcal/lb. DM                          | 0.52         | 0.62           |
| Ca: P                                     | 2.55         | 2.0            |

<sup>a</sup>Natural calf growing supplement contained min 26% CP, 3.4% Ca, 0.7% P, 1.38% K, no animal byproducts, and no medications.

<sup>b</sup>Conventional calf growing supplement contained min 26% CP, 3.4% Ca, 0.7% P, 1.38% K, no animal byproducts, 225 mg/lb Rumensin<sup>®</sup> and 0.5 mg/lb. MGA (melengestrol acetate).

<sup>c</sup>Natural calf finishing supplement contained Rumatex<sup>®</sup> Finisher at 0.5 ounces/day (as fed).

<sup>d</sup>Conventional calf finishing supplement provided Rumensin<sup>®</sup> at 300 mg and MGA (melengestrol acetate) at 0.50 mg (as fed).

<sup>e</sup>Mixed hay composed of equal parts barley and alfalfa-grass hays.

<sup>f</sup>Analytical results for growing diet are from composited samples; analytical results for finishing diet are from balanced feeding rations.

Pfizer Animal Health, N.Y.), while the natural supplement was unmedicated.

Diets were formulated for 2.20 pounds of daily gain; diets were isonitrogenous and isocaloric at the study start. Diets were fed once daily (9 a.m.) and slick bunk management was used to determine individual pen daily feed allotment. Calves had free access to water in ice-free automatic fence line water fountains. All calves were dewormed and vaccinated for respiratory and clostridial diseases, and conventional calves were implanted with a Ralgro implant (36 mg zeranol; Schering-Plough Animal Health Corp., Kenilworth, N.J.) at the start of their respective background periods.

Calves were checked daily for signs of bloat and respiratory illness. Calf weights were recorded on day 0, 28, 56, 59, 85 and 114. Initial and final weights were determined by weighing each animal following an overnight shrink before feeding, while interim body weights were measured as unshrunk weights recorded prior to feeding. Background diet samples were collected (day 1, 7, 36, 55, 74, 92 and 100), composited by treatment and analyzed by a commercial laboratory (Midwest Laboratories, Omaha, Neb.) for nutrient analysis.

After backgrounding, calves were shipped to the NDSU Carrington Research Extension Center for finishing on Jan. 28, 2008. Calves were dewormed, revaccinated for respiratory and clostridial diseases, and commingled into one of two finishing pens based on production practices (natural or conventional) at arrival. Calves were fed a 19:81 forage:concentrate diet (14 percent crude protein; 0.62 megacalories/pound of net energy for gain; finishing diet; dry-matter basis; Table 1) to a common end weight (1,100 pounds) and back fat thickness (0.4 inch) prior to harvest. The finishing supplement for the natural calves contained

Rumatec Finisher (Ralco Nutrition Inc., Marshall, Minn.), a natural feed additive (as previously described by Anderson et al., 2008) fed at 0.5 ounce/head/day. The conventional finishing supplement provided 300 mg Rumensin (Elanco Animal Health, Indianapolis, Ind.) and 0.5 mg MGA (melengestrol acetate, Pfizer Animal Health, N.Y.) per head per day.

Unshrunk calf weights were recorded (day 44, 86, 99, 119 and 133). Final weights were measured on all calves prior to shipping for harvest. Conventional calves were reimplanted (day 86; Synovex Choice, 100 mg trenbolone acetate and 14 mg estradiol benzoate; Wyeth Animal Health, Madison, N.J.) and all calves were given an ultrasound test to measure fat thickness for determining marketing date (day 99).

Calves ( $n = 77$ ) were harvested and individual carcass measurements collected on two dates (May 28 and June 11, 2008) at Tyson Foods (Dakota City, Neb.). On the first harvest date, 20 calves were harvested (10 from each pen), while the remaining calves were fed for 14 more days. Following a 24-hour chill, qualified university personnel, in concert with USDA graders, collected carcass data on the individual carcasses. Carcass traits measured included hot carcass weight; marbling scores; 12th rib fat thickness; longissimus area; kidney, pelvic and heart fat; and USDA yield grade. Calf growth and carcass traits were analyzed as a completely randomized design with the backgrounding pen serving as the experimental unit. Treatment means were separated by least square means following a protected F-test ( $P < 0.05$ ).

## Results and Discussion

*Growing Performance.* The effects of weaning and management strategies on calf performance and health are shown in Table 2. One calf (EWN) died because of bloat during the

background period. All performance data from the removed calf was deleted from subsequent performance analyses.

Additionally, three more calves were treated for ruminal bloat (EWC = one and EWN = two) and five calves were treated for respiratory illness (EWC = one, NWC = one, NWN = one and EWN = two). Of the calves treated for respiratory symptoms, three of the five calves required additional treatment with a second antibiotic (one calf each for EWN, EWC and NWN, respectively) during the background period. Natural calves treated with antibiotics remained with their respective pens during the background period. Because of treatment, these natural calves no longer were considered natural and were marketed as conventional calves at harvest, resulting in lost premiums for natural production. Calves were revaccinated for respiratory diseases on day 85 because of intermittent nasal discharges during backgrounding. Final veterinary medicine costs, bloat events, respiratory illness treatments and calf mortality were unaffected by TRT during backgrounding ( $P > 0.05$ ; Table 1).

By design, weaning date impacted weaning weights; early weaned calves were lighter and younger at weaning (422 pounds; 135 days of age) compared with normally weaned calves (553 pounds; 196 days of age;  $P < 0.001$ ). Weight gain, ADG and feed efficiencies (gain:feed) were greater for EWC compared with EWN during the first 28 days on feed ( $P \leq 0.01$ ), although feed cost/pound of gain did not differ across TRT ( $P = 0.05$ ). Similarly, in period two, weight gain, ADG and gain:feed were greater for EWC calves than EWN calves ( $P \leq 0.02$ ), while feed cost/pound of gain and veterinary medicine costs were similar across TRT ( $P \geq 0.05$ ). Dry-matter intakes (DMI) also were similar in this period, averaging 12.75 pounds ( $P = 0.85$ ). No significant differences

**Table 2. Effect of weaning and management strategies on calf performance and health.**

| Item   | Treatments        |                   |                   |                   | SEM <sup>e</sup> | P-value <sup>f</sup> |
|--|-------------------|-------------------|-------------------|-------------------|------------------|----------------------|
|  | EWC <sup>a</sup>  | EWN <sup>b</sup>  | NWC <sup>c</sup>  | NWN <sup>d</sup>  |                  |                      |
| No. head                                       | 20                | 21                | 19                | 21                | -                | -                    |
| Wean weight, lb.                               | 423 <sup>g</sup>  | 420 <sup>g</sup>  | 546 <sup>h</sup>  | 560 <sup>h</sup>  | 6.41             | < 0.001              |
| Age at weaning, days                           | 137 <sup>g</sup>  | 132 <sup>g</sup>  | 192 <sup>h</sup>  | 199 <sup>h</sup>  | 2.04             | < 0.001              |
| Initial weight, lb.                            | 426 <sup>g</sup>  | 456 <sup>g</sup>  | 574 <sup>h</sup>  | 572 <sup>h</sup>  | 6.39             | < 0.001              |
| Period 1, day 0-27                             |                   |                   |                   |                   |                  |                      |
| DMI, lb./d                                     | 10.3 <sup>g</sup> | 12.7 <sup>h</sup> | -                 | -                 | 0.36             | 0.01                 |
| 28-day gain, lb.                               | 72 <sup>h</sup>   | 37 <sup>g</sup>   | -                 | -                 | 5.93             | 0.01                 |
| ADG, lb./d                                     | 2.56 <sup>h</sup> | 1.32 <sup>g</sup> | -                 | -                 | 0.21             | 0.01                 |
| Gain:feed                                      | 0.25 <sup>h</sup> | 0.10 <sup>g</sup> | -                 | -                 | 0.02             | 0.01                 |
| Feed cost/lb gain, \$/lb.                      | 0.37              | 0.78              | -                 | -                 | 0.11             | 0.05                 |
| Veterinary medicine costs, \$/hd               | 9.97              | 10.02             | -                 | -                 | 1.77             | 0.98                 |
| Period 2, day 28-58                            |                   |                   |                   |                   |                  |                      |
| DMI, lb./d                                     | 12.7              | 12.8              | -                 | -                 | 0.30             | 0.85                 |
| 31-day gain, lb.                               | 49 <sup>h</sup>   | 30 <sup>g</sup>   | -                 | -                 | 2.66             | 0.007                |
| ADG, lb./d                                     | 1.52 <sup>h</sup> | 0.92 <sup>g</sup> | -                 | -                 | 0.08             | 0.006                |
| Gain:feed                                      | 0.12 <sup>h</sup> | 0.07 <sup>g</sup> | -                 | -                 | 0.009            | 0.02                 |
| Feed cost/lb. gain, \$/lb.                     | 0.75 <sup>g</sup> | 1.16 <sup>h</sup> | -                 | -                 | 0.07             | 0.01                 |
| Veterinary medicine costs, \$/hd               | 0.93 <sup>g</sup> | 1.11 <sup>g</sup> | 8.15 <sup>h</sup> | 7.79 <sup>h</sup> | 0.75             | < 0.001              |
| Period 3, day 59-84                            |                   |                   |                   |                   |                  |                      |
| DMI, lb./d                                     | 15.9              | 16.4              | 16.1              | 14.9              | 0.44             | 0.16                 |
| 26-day gain, lb.                               | 104               | 99                | 109               | 98                | 6.0              | 0.59                 |
| ADG, lb./d                                     | 4.01              | 3.80              | 3.74              | 3.44              | 0.20             | 0.33                 |
| Gain:feed                                      | 0.25              | 0.23              | 0.23              | 0.23              | 0.01             | 0.58                 |
| Feed cost/lb. gain, \$/lb.                     | 0.36              | 0.37              | 0.35              | 0.37              | 0.02             | 0.85                 |
| Veterinary medicine costs, \$/hd               | 0.06              | 0.16              | 0.47              | 0.41              | 0.32             | 0.77                 |
| Period 4, day 85-114                           |                   |                   |                   |                   |                  |                      |
| DMI, lb./d                                     | 17.9              | 18.6              | 18.4              | 18                | 0.55             | 0.77                 |
| 30-day gain, lb.                               | 43                | 70                | 44                | 39                | 10.9             | 0.25                 |
| ADG, lb./d                                     | 1.50              | 2.41              | 1.51              | 1.35              | 0.37             | 0.24                 |
| Gain:feed                                      | 0.08              | 0.13              | 0.08              | 0.08              | 0.02             | 0.25                 |
| Feed cost/lb. gain, \$/lb.                     | 1.37              | 0.68              | 1.61              | 1.20              | 0.42             | 0.49                 |
| Veterinary medicine costs, \$/hd               | 2.14              | 2.03              | 2.14              | 3.43              | 0.65             | 0.42                 |
| Overall, day 0-114                             |                   |                   |                   |                   |                  |                      |
| Background period end weight, lb.              | 694               | 700               | 726               | 711               | 13.6             | 0.42                 |
| DMI, lb./d                                     | 14.2 <sup>g</sup> | 14.8 <sup>g</sup> | 16.4 <sup>h</sup> | 16.5 <sup>h</sup> | 0.41             | 0.009                |
| 115-day gain, lb.                              | 268 <sup>h</sup>  | 235 <sup>h</sup>  | 153 <sup>g</sup>  | 138 <sup>g</sup>  | 12.81            | < 0.001              |
| ADG, lb./d                                     | 2.33              | 2.04              | 2.58              | 2.35              | 0.195            | 0.34                 |
| Gain:feed                                      | 0.164             | 0.137             | 0.157             | 0.142             | 0.011            | 0.31                 |
| Feed cost/lb gain, \$/lb.                      | 0.551             | 0.615             | 0.591             | 0.593             | 0.041            | 0.74                 |
| Veterinary medicine costs, \$/hd               | 12.34             | 13.73             | 10.75             | 11.63             | 2.02             | 0.77                 |
| Incidence of bloat, % of calves                | 5.0               | 19.0              | 0                 | 0                 | 9.82             | 0.34                 |
| Treatment for respiratory illness, % of calves |                   |                   |                   |                   |                  |                      |
| Once   | 5.56              | 9.52              | 5.56              | 4.76              | 6.62             | 0.95                 |
| Twice  | 5.56              | 4.76              | 0                 | 4.76              | 4.37             | 0.80                 |
| Mortality, % of calves                         | 0                 | 4.76              | 0                 | 0                 | 2.38             | 0.44                 |

<sup>a</sup>EWC: Early wean, conventional calves; wean date = Sept. 13 and 14, 2007.<sup>b</sup>EWN: Early wean, natural calves; wean date = Sept. 13 and 14, 2007.<sup>c</sup>NWC: Normal wean, conventional calves; wean date = Nov. 16 and 17, 2007.<sup>d</sup>NWN: Normal wean, natural calves; wean date = Nov. 16 and 17, 2007.<sup>e</sup>Standard error of mean; n = 3 observations per treatment.<sup>f</sup>P-value for F-test of treatment.<sup>g,h</sup>Means with different subscripts differ ( $P < 0.05$ ).

were observed among TRT for DMI, gain, ADG, feed efficiencies, veterinary medicine costs and feed cost/pound of gain for the remaining background periods (periods three and four;  $P \geq 0.16$ ).

Although background ending weights were similar across TRT ( $708 \pm 13.6$  pounds;  $P = 0.42$ ) after 115 days, background weight gain was impacted by TRT (268, 235, 153 and 138 pounds for EWC, EWN, NWC and NWN, respectively;  $P < 0.001$ ). Calf weight gain was influenced directly by the number of days on feed. Early weaned calves spent 56 days more on higher energy rations (based on weaning date) as compared with the NW calves (EW = 115 days vs. NW = 59 days). Although EWC and EWN calves had higher feed costs at the end of 115 days than NWC and NWN calves (data not shown), feed cost/pound of gain was comparable, averaging \$0.588/pound for 115 days ( $P = 0.74$ ). Overall, EW calves had 11.9 percent lower DMI intakes as compared with NW calves ( $P = 0.009$ ). This may be attributed to their weaning date and weight, incidences of bloat and respiratory illness events that affected the calves, resulting in lower DMI during periods one and two of the background phase.

*Finishing Performance.* The effects of weaning and management strategies on calf finishing performance are reported in Table 3. During the finish period, one NWN calf was removed from the study because of chronic infection and one EWC calf died due to complications from a broken shoulder. All performance data from the two removed calves was deleted from subsequent performance analyses. Additionally, feed intake data was not analyzed during finishing, since treatment pens were commingled into two pens during the finish period. Body weights were greatest for NWC calves during periods one and two, with no differences for gain and ADG

among TRT ( $P = 0.02$ ). This difference in weight gain can be attributed to ionophore (Rumensin) feeding in the conventional diet and implant efficacy. Ionophores can increase ADG by 1 percent to 6 percent and improve feed efficiency by 6 percent to 8 percent (Preston, 1987). When ionophores and implants are used together at the same time, they have a synergistic effect (additive) on an animal's weight gain and feed efficiency. This additive effect can increase daily gains by 0.15 to 0.20 pound/day.

The Ralgro implants still were working (potent) to improve feed efficiency in NWC calves during finish periods one and two. However, the Ralgro implants for the EWC calves had expired (run out) by this time (Ralgro implant potency period is approximately 90 days post-implanting). At the start period three of the finishing phase, all conventional calves (EWC and NWC) were implanted with Synovex Choice. During period three, NWC had the greatest weight gain and ADG, followed by EWC, EWN and NWN calves ( $P = 0.002$ ).

Performance data for the 20 early harvested calves (May 28, 2008; EWC = two, EWN = three, NWC = eight and NWN = seven) is shown as period four (Table 3). Of the few head harvested, EWC, NWC and NWN calves had similar ending weights, which were greater than EWN calves ( $P = 0.03$ ). The performance data for the remaining 58 calves is reported in period five. For these calves, conventionally managed calves (EWC and NWC) weighed the heaviest, gained the most and had the greatest ADG when compared with naturally managed calves within their respective weaning group (EWN and NWN;  $P \leq 0.03$ ). Overall, the NWC and EWC calves had the greatest gains (total gain and ADG) compared with EWN and NWN calves for the 133-day finish period.

When the remaining calves ( $n = 58$ ) were weighed before shipping for harvest (June 10, 2007), the decision was made to send one EWC calf to a local abattoir (Barton Meats, Carrington, N.D.) for harvest because this calf would be discounted as a small carcass at the commercial plant and required more days on feed to reach market weight. In this study, most carcass traits were similar at harvest ( $P > 0.05$ ) regardless of TRT, with the exception of hot carcass weights ( $P = 0.02$ , Table 3) which followed the trend of final weight. Harvest weights were 6 percent heavier for conventional calves (EWC and NWC) as compared with natural calves (EWN and NWN).

## Implications

In the present study, calves that were managed as "natural," with no growth-promoting implants, ionophores, or antibiotics, gained less weight during backgrounding and finishing as compared with their contemporaries that were managed conventionally (implanted with a growth-promoting implant, fed an ionophore, and treated with antibiotics during periods of morbidity). Harvest weights were 6 percent heavier for conventional calves as compared with natural calves. Additional research on breakeven costs for naturally raised versus conventionally raised calves is needed. In this trial, early weaned (135-day-old) May-born calves tended to gain less weight during the background and finish phases when compared with normally weaned (195-day-old) calves. While early weaning is a viable option for managing grazing lands during drought, the result may be lighter calves at harvest.

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**Table 3. Effect of weaning and management strategies on calf finishing performance and carcass traits.**

| Item                              | Treatments          |                   |                   |                     | SEM <sup>e</sup> | P-value <sup>f</sup> |
|-----------------------------------|---------------------|-------------------|-------------------|---------------------|------------------|----------------------|
|                                   | EWC <sup>a</sup>    | EWN <sup>b</sup>  | NWC <sup>c</sup>  | NWN <sup>d</sup>    |                  |                      |
| Finishing performance             |                     |                   |                   |                     |                  |                      |
| No. head                          | 19                  | 20                | 19                | 20                  | -                | -                    |
| Initial weight, lb.               | 694                 | 700               | 726               | 711                 | 13.6             | 0.42                 |
| Period 1, day 0-44                |                     |                   |                   |                     |                  |                      |
| Weight, lb.                       | 821 <sup>h,i</sup>  | 804 <sup>h</sup>  | 878 <sup>j</sup>  | 853 <sup>i,j</sup>  | 13.7             | 0.02                 |
| 43-day gain, lb.                  | 125                 | 115               | 147               | 133                 | 7.10             | 0.06                 |
| ADG, lb./d                        | 2.91                | 2.67              | 3.42              | 3.09                | 0.17             | 0.06                 |
| Period 2, day 45-86               |                     |                   |                   |                     |                  |                      |
| Weight, lb.                       | 967 <sup>h</sup>    | 969 <sup>h</sup>  | 1045 <sup>i</sup> | 1009 <sup>h,i</sup> | 15.8             | 0.02                 |
| 42-day gain, lb.                  | 151                 | 165               | 168               | 164                 | 4.69             | 0.14                 |
| ADG, lb./d                        | 3.60                | 3.92              | 3.99              | 3.90                | 0.11             | 0.14                 |
| Period 3, day 87-99               |                     |                   |                   |                     |                  |                      |
| Weight, lb.                       | 1013 <sup>h</sup>   | 1007 <sup>h</sup> | 1105 <sup>i</sup> | 1045 <sup>h</sup>   | 17.1             | 0.01                 |
| 13-day gain, lb.                  | 45 <sup>h</sup>     | 38 <sup>h</sup>   | 60 <sup>i</sup>   | 36 <sup>h</sup>     | 3.13             | 0.002                |
| ADG, lb./d                        | 3.48 <sup>h</sup>   | 2.94 <sup>h</sup> | 4.61 <sup>i</sup> | 2.73 <sup>h</sup>   | 0.24             | 0.002                |
| Period 4, day 100-119             |                     |                   |                   |                     |                  |                      |
| No. head                          | 2                   | 3                 | 8                 | 7                   | -                | -                    |
| Weight, lb.                       | 1206 <sup>i</sup>   | 1099 <sup>h</sup> | 1257 <sup>i</sup> | 1215 <sup>i</sup>   | 29.4             | 0.03                 |
| 20-day gain, lb.                  | 89 <sup>i</sup>     | 51 <sup>h</sup>   | 83 <sup>i</sup>   | 48 <sup>h</sup>     | 8.75             | 0.03                 |
| ADG, lb./d                        | 4.43 <sup>i</sup>   | 2.54 <sup>h</sup> | 4.17 <sup>i</sup> | 2.38 <sup>h</sup>   | 0.44             | 0.03                 |
| Period 5, day 100-133             |                     |                   |                   |                     |                  |                      |
| No. head                          | 17                  | 17                | 11                | 13                  | -                | -                    |
| Weight, lb.                       | 1128 <sup>h,i</sup> | 1097 <sup>h</sup> | 1162 <sup>i</sup> | 1087 <sup>h</sup>   | 15               | 0.03                 |
| 34-day gain, lb.                  | 127 <sup>i</sup>    | 97 <sup>h</sup>   | 130 <sup>i</sup>  | 93 <sup>h</sup>     | 5.26             | 0.002                |
| ADG, lb./d                        | 3.73 <sup>i</sup>   | 2.85 <sup>h</sup> | 3.82 <sup>i</sup> | 2.73 <sup>h</sup>   | 0.15             | 0.002                |
| Overall, day 0-133                |                     |                   |                   |                     |                  |                      |
| Final weight, lb.                 | 1136 <sup>h</sup>   | 1097 <sup>h</sup> | 1211 <sup>i</sup> | 1122 <sup>h</sup>   | 16.1             | 0.005                |
| Total gain, lb.                   | 443 <sup>i</sup>    | 408 <sup>h</sup>  | 484 <sup>i</sup>  | 411 <sup>h</sup>    | 10.3             | 0.003                |
| ADG, lb./d                        | 3.38 <sup>i</sup>   | 3.11 <sup>h</sup> | 3.82 <sup>j</sup> | 3.22 <sup>h,i</sup> | 0.11             | 0.01                 |
| Carcass Traits                    |                     |                   |                   |                     |                  |                      |
| No. head                          | 18                  | 20                | 19                | 20                  | -                | -                    |
| Hot carcass weight, lb.           | 672 <sup>h</sup>    | 644 <sup>h</sup>  | 721 <sup>i</sup>  | 659 <sup>h</sup>    | 13.7             | 0.02                 |
| Marbling score <sup>g</sup>       | 409                 | 430.7             | 403.3             | 425.3               | 15.3             | 0.57                 |
| 12th rib fat thickness, in.       | 0.57                | 0.51              | 0.56              | 0.58                | 0.04             | 0.68                 |
| Longissimus area, in <sup>2</sup> | 11.7                | 11.2              | 12                | 11.5                | 0.36             | 0.53                 |
| Kidney, pelvic and heart fat, %   | 1.93                | 2.07              | 1.90              | 1.97                | 0.07             | 0.40                 |
| USDA Yield grade (adjusted)       | 3.20                | 3.11              | 3.23              | 3.19                | 0.15             | 0.94                 |

<sup>a</sup>EWC: Early wean, conventional calves; wean date = Sept. 13 and 14, 2007.

<sup>b</sup>EWN: Early wean, natural calves; wean date = Sept. 13 and 14, 2007.

<sup>c</sup>NWC: Normal wean, conventional calves; wean date = Nov. 16 and 17, 2007.

<sup>d</sup>NWN: Normal wean, natural calves; wean date = Nov. 16 and 17, 2007.

<sup>e</sup>Standard error of mean; n = 3 observations per treatment.

<sup>f</sup>P-value for F-test of treatment.

<sup>g</sup>Light = 200 to 299; Small = 300 to 399; Modest = 400 to 499; Moderate = 500 to 599.

<sup>h,i,j</sup>Means with different subscripts differ ( $P < 0.05$ ).

# Effects of distillers dried grains with solubles on growing and finishing steer intake, performance, carcass characteristics, color and sensory attributes

J.L. Leupp<sup>1</sup>, G.P. Lardy<sup>1</sup>, M.L. Bauer<sup>1</sup>, K.K. Karges<sup>2</sup>, M.L. Gibson<sup>2</sup>, J.S. Caton<sup>1</sup> and R.J. Maddock<sup>1</sup>

*The objectives of this study were to determine the effects of distillers dried grains with solubles on growing and finishing performance, carcass characteristics and meat quality traits. These data suggest distillers dried grains with solubles (DDGS) can be included at 30 percent dietary dry matter (DM) in both the growing and finishing period, partially replacing dry-rolled corn, with no detrimental effects on performance, carcass characteristics or sensory attributes, although DDGS may negatively affect color.*

## Summary

Seventy-two crossbred and purebred beef steers (653 ± 20 pounds initial body weight [BW]) were used in a completely randomized design to determine effects of distillers dried grains with solubles (29.2 percent crude protein [CP], 9.7 percent fat, DM basis; DDGS) on growing and finishing steer intake, performance, carcass and meat quality traits. The study contained two feeding periods, growing and finishing, which resulted in four treatments: 0:0, 30:0, 0:30 and 30:30 (diet DDGS percentage fed during growing and finishing periods, respectively). Steers were individually fed a growing diet (65 percent concentrate) for 57 days then acclimated to and fed a finishing diet (90 percent concentrate) for 80 or 145 days. Dietary ingredients included dry-rolled corn, corn silage, grass hay, concentrated separator byproduct and supplement.

During the growing period, dry-matter intake (DMI) was not different ( $P \geq 0.63$ ). Steer performance, including average daily gain (ADG) and gain:feed (G:F), were not affected ( $P \geq 0.14$ ) by treatment during the growing period and final BW at the end of the growing period was not different ( $P = 0.99$ ). During the finishing period, DMI, ADG and G:F were not different ( $P \geq 0.22$ ). As a result, final BW was not different ( $P \geq 0.28$ ). Carcass traits (ribeye area; 12th rib fat; kidney, pelvic

and heart fat (KPH); yield grade; and marbling) were not different ( $P \geq 0.16$ ).

Results from the trained panel indicated no differences ( $P \geq 0.16$ ) in tenderness; however, steaks from steers fed 30 percent DDGS during the finishing period tended ( $P = 0.10$ ) to be juicier and more flavorful than steaks from control steers. Inclusion of 30 percent DDGS in the growing period tended to lower L\* (muscle lightness) ( $P = 0.08$ ) and lowered b\* (muscle yellowness;  $P = 0.01$ ) of steaks. Overall feeding of DDGS lowered b\* ( $P = 0.02$ ) compared with feeding dry-rolled corn (0:0). Feeding DDGS during the finishing period lowered a\* (muscle redness;  $P < 0.001$ ) of steaks. Furthermore, overall feeding of DDGS lowered a\* ( $P < 0.001$ ) compared with feeding dry-rolled corn (0:0). Feeding 30 percent DDGS did not impact any performance or carcass characteristics but did influence steak sensory attributes and color.

## Introduction

Distillers dried grains with solubles can be used as a protein and energy source depending on the amount included in the diet (Ham et al., 1994). Feeding up to 40 percent wet or dry distillers grains in growing and finishing diets improves ADG and G:F in steers compared with feeding dry-rolled corn only (Ham et al., 1994).

<sup>1</sup>Department of Animal Sciences, North Dakota State University, Fargo, ND 58108

<sup>2</sup>Dakota Gold Research Association, Sioux Falls, SD 57104

Beef consumers want a high-quality product that is tender, juicy and flavorful. Research is limited in evaluating effects of feeding DDGS to growing and finishing steers on meat quality. Roeber et al. (2005) fed finishing Holstein steers up to 50 percent distillers dried grains (DDG) and reported no differences in tenderness or sensory traits compared with corn-based diets.

Little quantitative information is available on the effects of short- and long-term feeding of DDGS to steers on performance and carcass quality. Therefore, our objectives were to determine the effects of DDGS on growing and finishing steer intake, performance, carcass characteristics, color and sensory attributes.

## Materials and Methods

Seventy-two crossbred and purebred beef steers were used in a completely randomized design. The study contained two feeding periods, growing and finishing, which resulted in four treatments: 0:0, 30:0, 0:30 and 30:30 (diet DDGS percentage fed during growing and finishing periods, respectively). Steers were fed individually a growing diet (65 percent concentrate) for 57 days then acclimated for 14 days to a finishing diet (90 percent concentrate) and fed for 80 or 145 days. Diets were based on dry-rolled corn, corn silage, grass hay, concentrated separator byproduct and supplement (Table 1). Diets included 27.5 parts per million (ppm) of Rumensin and 11 ppm of Tylan and were formulated to contain a minimum of 12.5 percent CP, 0.70 percent calcium (Ca) and 0.30 percent phosphorus (P).

Steers were assigned to treatment and fed individually. Steers received a Ralgro implant on day 0 and Revalor IS on day 60. Final weights were calculated from hot carcass weight (HCW) using an average dressing percentage of 62.5 percent and a 4

percent shrink. Average daily gain and G:F were calculated based on this data. Cattle were sent to a commercial abattoir for slaughter on either March 24 or May 28. Steers marketed on March 24 were estimated to have at least 0.4 inch backfat as measured by ultrasound. The remaining steers were marketed on May 28 when the majority of the steers had an estimated 0.4 inch backfat as measured by ultrasound.

One steak from each steer was used for simulated retail display shelf-life analysis. A colorimeter was used to measure longissimus lean L\* (muscle lightness), a\* (muscle redness) and b\* (muscle yellowness) color space values through the overwrap

polyvinyl chloride (PVC) film for each postmortem display day at 9 a.m. each day.

One steak from each steer was used for evaluation of tenderness using the Warner-Bratzler shear force machine (WBSF). Steaks were thawed for 24 hours at 35 degrees Fahrenheit, weighed and then cooked in clamshell-style grills at 350 F until the steaks reached an internal temperature of 158 F. Six 0.5-inch cores from each steak were removed parallel to the muscle fiber.

Sensory panel analysis was conducted with a trained panel. Steaks were thawed at 35 F for 24 hours and cooked as previously described for

**Table 1. Formulated dietary composition of growing and finishing diets containing 0 or 30 percent corn distillers dried grains with solubles offered to beef steers (% dietary DM).**

| Item                              | Diet, % of dietary DM          |          |                      |          |
|-----------------------------------|--------------------------------|----------|----------------------|----------|
|                                   | Growing                        |          | Finishing            |          |
|                                   | 0% DDGS <sup>1</sup>           | 30% DDGS | 0% DDGS <sup>1</sup> | 30% DDGS |
| Dry-rolled corn                   | 50                             | 20       | 80                   | 50       |
| DDGS                              | —                              | 30       | —                    | 30       |
| Corn silage                       | 20                             | 20       | 5                    | 5        |
| Grass hay                         | 20                             | 20       | 5                    | 5        |
| CSB <sup>2</sup>                  | 5                              | 5        | 5                    | 5        |
| Wheat middlings                   | 2.18                           | 2.53     | 1.00                 | 2.18     |
| Soybean meal                      | —                              | —        | 1.00                 | —        |
| Limestone                         | 1.40                           | 2.10     | 1.58                 | 2.45     |
| Urea                              | 0.75                           | —        | 0.75                 | —        |
| Dicalcium phosphate               | 0.30                           | —        | 0.30                 | —        |
| Salt                              | 0.25                           | 0.25     | 0.25                 | 0.25     |
| Trace mineral premix <sup>3</sup> | 0.05                           | 0.05     | 0.05                 | 0.05     |
| Vitamin A, D premix <sup>4</sup>  | 0.02                           | 0.02     | 0.02                 | 0.02     |
| Vitamin E premix <sup>5</sup>     | 0.02                           | 0.02     | 0.02                 | 0.02     |
| Monensin premix <sup>6</sup>      | 0.02                           | 0.02     | 0.02                 | 0.02     |
| Tylosin premix <sup>7</sup>       | 0.01                           | 0.01     | 0.01                 | 0.01     |
|                                   | -----Analyzed composition----- |          |                      |          |
| CP                                | 12.8                           | 17.9     | 16.1                 | 22.7     |
| NDF                               | 37.3                           | 39.5     | 26.1                 | 33.2     |
| ADF                               | 20.3                           | 18.5     | 9.4                  | 10.0     |
| Ca                                | 1.23                           | 1.23     | 1.87                 | 2.13     |
| P                                 | 0.32                           | 0.44     | 0.54                 | 0.71     |

<sup>1</sup>Distillers dried grains with solubles; nutrient content of DDGS used averaged 29.2% CP, 34.7% NDF, 9.5% ADF, 9.7% crude fat, 0.03% Ca and 0.81% P.

<sup>2</sup>Concentrated separator byproduct (de-sugared molasses).

<sup>3</sup>Contained 250 ppm Co, 25.6 ppt Cu, 1.05 ppt I, 6.50 ppt Fe, 40.0 ppt Mn and 160 ppt Zn.

<sup>4</sup>Contained 22.0 kIU/pound vitamin A and 2.10 kIU/pound vitamin D.

<sup>5</sup>Contained 20 IU/kg vitamin E.

<sup>6</sup>Contained 176.4 ppt monensin (Elanco Animal Health, Indianapolis, Ind.) to provide 27.5 ppm of dietary DM.

<sup>7</sup>Contained 88.2 ppt tylosin (Elanco Animal Health, Indianapolis, Ind.) to provide 11 ppm of dietary DM.

WBSF evaluation. Steaks then were cut into pieces of approximately 0.5 by 0.5 by 1 inch and served to panelists for evaluation. Panelists scored 10 samples each day using an 8-point scale where 1 equaled extremely tough, dry and bland and 8 equaled extremely tender, juicy and intense beef flavor.

## Results

During the growing period, two steers from the 30 percent DDGS treatment were removed from the study due to conditions unrelated to treatment. One steer was removed prior to initiation of treatments and the other removed due to chronic bloat; therefore, 70 steers were used during the growing period. Steers were fed growing diets for 57 days. Initial BW of steers was not different ( $P = 0.57$ ) and averaged  $653 \pm 20$  pounds. Steer performance, including DMI (22.5 pounds/day), ADG (3.85 pounds/day) and G:F (0.17 pounds gain/pound feed) were not affected ( $P \geq 0.14$ ) by treatment

during the growing period. Final BW at the end of the growing period also was not different ( $P = 0.99$ ) and averaged  $937 \pm 13$  pounds.

Three steers were removed from the data set due to low feed intakes during the finishing portion of the trial. Two of the steers removed were on the 30 percent DDGS treatment and one steer was from the 0 percent DDGS treatment. Days fed during the finishing period were not different ( $P \geq 0.27$ ; Table 2) across treatments and averaged  $102 \pm 8$  days. No treatment differences ( $P \geq 0.22$ ) were observed for DMI, ADG or G:F. Ham et al. (1994) fed cattle 40 percent DDGS, which partially replaced dry-rolled corn in finishing diets, and observed improved ADG and G:F when compared with cattle consuming dry-rolled corn diets. In the current study, no differences ( $P \geq 0.28$ ) in final BW were observed.

Similar to final BW, no differences were found in HCW ( $P \geq 0.28$ ;  $791 \pm 22$  pounds; Table 2). Longissimus muscle area ( $12.1 \pm 0.5$  inch<sup>2</sup>), 12th rib fat thickness ( $0.50 \pm 0.04$  inch) and KPH ( $2.48 \pm 0.16$  percent) were not different ( $P \geq 0.16$ ); therefore, no differences ( $P \geq 0.35$ ;  $3.33 \pm 0.17$ ) were observed for yield grade. No differences ( $P \geq 0.43$ ) were observed for marbling, which averaged 431 (small<sup>0</sup> = 400; Table 2).

Warner-Bratzler shear force and cooking loss were not different ( $P \geq 0.13$ ) across treatments (Table 3). Results from the trained panel indicated no differences ( $P \geq 0.16$ ) in tenderness, which averaged  $6.03 \pm 0.16$  (8-point hedonic scale; Table 3); however, steaks from steers fed 30 percent DDGS during the finishing period tended ( $P = 0.10$ ) to be juicier and more flavorful than steaks from the control steers ( $6.01$  vs.  $5.83 \pm 0.11$  and  $6.02$  vs.  $5.89 \pm 0.08$ , respectively).

**Table 2. Performance and carcass characteristics of steers fed growing and finishing diets containing 0 or 30 percent corn distillers dried grains with solubles.**

| Item                     | Treatment <sup>1</sup> |      |      |       | SEM <sup>2</sup> | Contrast <sup>3</sup> |           |                            |
|--------------------------|------------------------|------|------|-------|------------------|-----------------------|-----------|----------------------------|
|                          | 0:0                    | 30:0 | 0:30 | 30:30 |                  | Growing               | Finishing | Corn vs. DDGS <sup>4</sup> |
| Steers, n                | 18                     | 15   | 16   | 18    | —                | —                     | —         | —                          |
| Finishing period, d      | 99                     | 106  | 97   | 106   | 8                | 0.27                  | 0.87      | 0.61                       |
| Performance              |                        |      |      |       |                  |                       |           |                            |
| Final BW, lb             | 1193                   | 1226 | 1204 | 1239  | 33               | 0.28                  | 0.73      | 0.41                       |
| DMI, lb/d                | 18.4                   | 18.8 | 19.9 | 17.6  | 1.5              | 0.51                  | 0.92      | 0.80                       |
| ADG, lb/d                | 3.46                   | 3.22 | 3.51 | 3.40  | 0.15             | 0.22                  | 0.48      | 0.58                       |
| G:F, lb/lb               | 0.22                   | 0.19 | 0.19 | 0.21  | 0.03             | 0.91                  | 0.89      | 0.52                       |
| Carcass Characteristics  |                        |      |      |       |                  |                       |           |                            |
| HCW, lb                  | 776                    | 798  | 783  | 807   | 22               | 0.28                  | 0.73      | 0.41                       |
| LM area, in <sup>2</sup> | 12.1                   | 12.5 | 11.8 | 11.8  | 0.5              | 0.60                  | 0.34      | 0.95                       |
| 12th rib fat, in         | 0.46                   | 0.53 | 0.48 | 0.52  | 0.04             | 0.16                  | 0.90      | 0.21                       |
| KPH, %                   | 2.41                   | 2.60 | 2.44 | 2.47  | 0.16             | 0.46                  | 0.73      | 0.59                       |
| Marbling <sup>5</sup>    | 430                    | 448  | 440  | 407   | 21               | 0.71                  | 0.43      | 0.96                       |
| Yield grade              | 3.20                   | 3.33 | 3.44 | 3.33  | 0.17             | 0.95                  | 0.45      | 0.35                       |

<sup>1</sup>Dietary distillers dried grains with solubles percentage fed during growing and finishing periods, respectively.

<sup>2</sup>n = 15.

<sup>3</sup>Growing = main effect of feeding distillers dried grains with solubles during the growing period; Finishing = main effect of feeding distillers dried grains with solubles during the finishing period; Corn vs. DDGS = feeding dry-rolled corn (0:0) vs. feeding distillers dried grains with solubles during the growing and finishing periods (30:0 + 0:30 + 30:30).

<sup>4</sup>Corn distillers dried grains with solubles.

<sup>5</sup>Small<sup>0</sup> = 400.

Steaks from steers consuming 30 percent DDGS during the growing period tended to have lower L\* ( $P = 0.08$ ) and lowered b\* ( $P = 0.01$ ) color values when compared with steaks from steers consuming 0 percent DDGS during the growing period (Table 3). Feeding DDGS regardless of period resulted in lower L\* ( $P = 0.04$ ) and b\* ( $P = 0.02$ ) compared with feeding dry-rolled corn (0:0). Feeding DDGS during the finishing period lowered a\* ( $P < 0.001$ ) of steaks. Furthermore, feeding DDGS lowered a\* ( $P < 0.001$ ) compared with feeding dry-rolled corn (0:0). A finishing period x display day interaction ( $P = 0.02$ ) was present for a\* values in steaks from steers fed 30 percent DDGS and decreased a\* at a faster rate than in steers fed 0 percent DDGS. Reasons

for a faster decline in a\* of steaks from steers fed DDGS may be attributed to increased oxidation of unsaturated fatty acids and enzymatic-reducing systems that control metmyoglobin levels in meat (Gray et al., 1996).

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**Table 3. Shear force, color analysis and sensory characteristics of steaks from steers fed growing and finishing diets containing 0 or 30 percent corn distillers dried grains with solubles.**

| Item                                 | Treatment <sup>1</sup> |       |       |       | SEM <sup>2</sup> | Contrast <sup>3</sup> |           |                            |
|--------------------------------------|------------------------|-------|-------|-------|------------------|-----------------------|-----------|----------------------------|
|                                      | 0:0                    | 30:0  | 0:30  | 30:30 |                  | Growing               | Finishing | Corn vs. DDGS <sup>4</sup> |
| Steaks, n                            | 17                     | 15    | 16    | 18    | —                | —                     | —         | —                          |
| Shear force, lb                      | 8.20                   | 8.49  | 7.98  | 7.52  | 0.49             | 0.86                  | 0.19      | 0.68                       |
| Cooking loss <sup>5</sup> , oz       | 1.77                   | 1.51  | 1.64  | 1.62  | 0.11             | 0.17                  | 0.92      | 0.13                       |
| Color <sup>6</sup>                   |                        |       |       |       |                  |                       |           |                            |
| L*                                   | 49.03                  | 48.69 | 48.77 | 48.48 | 0.19             | 0.08                  | 0.19      | 0.04                       |
| a*                                   | 21.69                  | 22.33 | 20.27 | 19.99 | 0.24             | 0.41                  | <0.001    | <0.001                     |
| b*                                   | 8.74                   | 8.27  | 8.56  | 8.21  | 0.18             | 0.01                  | 0.44      | 0.02                       |
| Sensory characteristics <sup>7</sup> |                        |       |       |       |                  |                       |           |                            |
| Tenderness                           | 6.02                   | 5.81  | 6.16  | 6.11  | 0.16             | 0.40                  | 0.16      | 0.97                       |
| Juiciness                            | 5.84                   | 5.82  | 5.98  | 6.03  | 0.11             | 0.87                  | 0.10      | 0.39                       |
| Flavor                               | 6.04                   | 5.74  | 5.99  | 6.05  | 0.08             | 0.13                  | 0.10      | 0.23                       |

<sup>1</sup>Dietary distillers dried grains with solubles percentage fed during growing and finishing periods, respectively.

<sup>2</sup>n = 15.

<sup>3</sup>Growing = main effect of feeding distillers dried grains with solubles during the growing period; Finishing = main effect of feeding distillers dried grains with solubles during the finishing period; Corn vs. DDGS = feeding dry-rolled corn (0:0) vs. feeding distillers dried grains with solubles during the growing and finishing periods (30:0 + 0:30 + 30:30).

<sup>4</sup>Corn distillers dried grains with solubles.

<sup>5</sup>Initial weight used as a covariate.

<sup>6</sup>L\* = white to black (100 = white, 0 = black); a\* = red to green (35 = red, -35 = green); b\* = yellow to blue (35 = yellow, -35 = blue).

<sup>7</sup>Tenderness (8 = extremely tender, 1 = extremely tough); juiciness (8 = extremely juicy, 1 = extremely dry); flavor (8 = extremely flavorful, 1 = extremely bland).

# Eastern Dakota Cattle Feedout Project IV: Discovering value in North Dakota calves

Progress Report Year 2007-2008

Karl Hoppe<sup>1</sup>, Bill Hodous<sup>2</sup>, Brad Brummond<sup>3</sup>, Lance Brower<sup>4</sup> and Mark Miller<sup>5</sup>

*The Eastern Dakota Cattle Feedout project was developed to discover the actual value of spring-born beef steer calves, provide comparisons among herds, and benchmark feeding and carcass performance for contributing North Dakota cow herds. Cattle consigned to the feedout project averaged 665 pounds upon delivery to the Pipestem Feeders Feedlot, Carrington, N.D., on Nov. 29, 2007. After an average 167-day feeding period with 2.67 percent death loss, cattle averaged 1,217 pounds (at plant, shrunk weight). Average daily feed intake per head, as fed, was 30.3 pounds, while pounds of feed, as fed basis, required per pound of gain were 10.1. Diet dry matter was 65 percent. The calves averaged 423 days of age at harvest. Overall pen average daily gain with death loss included was 3 pounds. Feed cost was \$0.585 per pound and total cost of gain without interest was \$0.846.*

*The cattle were harvested on April 18, May 16 and June 3, 2008. Marbling scores averaged 422 (low choice). Overall loss before deducting interest expense per head was \$33.92. Average profit before interest expense for the top five groups of six head of calves with superior*

*growth and carcass traits was \$61.84 per head while the bottom five groups of poorer performing calves averaged a loss per head of \$61.65. The wide range in profitability indicates the diversity of the cattle consigned by North Dakota cattle producers into a feed out project.*

## Introduction

Determining calf value is a continuing experience for cow-calf producers. A companion project, the Dakota Feeder Calf Show, was developed to identify differences in cattle fed to finish under similar conditions. The Eastern Dakota Cattle Feedout commences 1½ months later than the Dakota Feeder Calf Show feedout. Previous trials (Hoppe et.al., 1997) support cost-effective feeding of cattle to finish in North Dakota. These feedout projects were developed to explore differences in feedlot and carcass performance in cattle fed in North Dakota.

## Materials and Methods

The Eastern Dakota Feedout Project was developed for cattle producers willing to consign steer calves to a feedout project where cattle are comingled. The calves were received in groups of six or more calves on either Nov. 28, 2007, at Lake Region Livestock Auction, Devils Lake, N.D., or Nov. 29, 2007, at the Pipestem Feeders feedlot, Carrington, N.D. The calves were weighed individually; ear tagged; vaccinated for virals IBR, BVD,

PI3 and BRSV; and treated with an antiparasiticide. Cattle were implanted with Revalor IS 42 days after arrival at the feed yard.

The calves were transitioned to a finishing diet through a series of step-up rations containing increased amounts of grain. After a six week step-up period, the calves were fed an 80 percent grain diet.

An open house was held on Feb.14, 2008, at the NDSU Carrington Research Extension Center Livestock Unit, Carrington, N.D., and Pipestem Feeders, where the owners viewed the calves and discussed marketing conditions. The calves were weighed every six to eight weeks and updated performance reports were sent to the owners.

Cattle (245 head) were harvested at Tyson Fresh Meats, Dakota City, Neb., using a grid basis with premiums and discounts. Carcass data was collected after harvest. Ten head were not harvested due to small cattle size and were returned to the owner.

Consignee meetings were held in Napoleon, Park River and Devils Lake, N.D., to discuss cattle performance after the project was completed.

## Results and Discussion

Cattle consigned to the Dakota Feeder Calf Show Feedout project averaged 665 pounds upon delivery to the Pipestem Feeders Feedlot, Carrington,

<sup>1</sup>North Dakota State University Extension Service, Carrington Research Extension Center, Carrington, N.D.

<sup>2</sup>NDSU Extension Service, Ramsey County

<sup>3</sup>NDSU Extension Service, Walsh County

<sup>4</sup>NDSU Extension Service, Logan County

<sup>5</sup>NDSU Extension Service, Rolette County

N.D., on Nov. 29, 2007. After an average 167-day feeding period, cattle averaged 1,217 pounds (at plant, shrunk weight). Seven deaths, or a 2.67 percent death loss, occurred during the feeding period. Average daily feed intake per head was 30.3 pounds on an as-fed basis and 19.7 pounds on a dry-matter basis. Pounds of feed required per pound of gain were 10.1 on an as-fed basis and 6.5 pounds on a dry-matter basis.

The number of cattle consigned was 262. Ten head were removed from the feedout prior to harvest and returned to the owner due to low beginning weight and reduced feed yard performance. Seven head died due to respiratory infections.

The overall feed cost per pound of gain was \$0.585. The overall yardage cost per pound of gain was \$0.083. The combined cost per pound of gain, including feed, yardage, veterinary, trucking and other expenses except interest, was \$0.846. Trucking to Tyson Fresh Meats, Dakota City, Neb., averaged \$48.04 per head.

Ultrasound was used to determine backfat thickness and ribeye marbling on April 8, 2008. Cattle were sorted by weight and backfat thickness and harvested on April 18, May 15 or June 3, 2008. The carcass characteristics were collected after harvest. Market value was based on actual carcass price received (Table 1).

Cattle performance was reported individually to the consignees. Average cattle performance by consignee is reported in Table 2.

Overall, calves averaged 422.7 days of age and averaged 1,217 pounds per head at harvest. The overall average daily gain was 3.20 pounds, while weight per day of age was 2.86 pounds. The overall carcass marbling score was 423 (low choice/small marbling).

**Table 1. Carcass characteristics and grid prices for Eastern Dakota Feedout Project cattle.**

| Harvest date | April 8, 2008 |         | May 15, 2008 |         | June 3, 2008 |         |
|--------------|---------------|---------|--------------|---------|--------------|---------|
|              | carcass       | %       | \$/cwt*      | %       | \$/cwt       | %       |
| Prime        | 2.3           | 13.43   | 0.0          | 11.23   | 0.0          | 10.68   |
| CAB          | 18.6          | 2.40    | 8.8          | 4.75    | 3.9          | 3.50    |
| Choice       | 58.2          | 0.00    | 57.6         | 0.00    | 44.8         | 0.00    |
| Select       | 18.6          | (2.32)  | 29.6         | (3.29)  | 43.4         | (4.41)  |
| Standard     | 2.3           | (13.22) | 4.0          | (10.61) | 7.9          | (12.56) |
| YG 1         | 2.3           | 4.00    | 13.6         | 4.00    | 10.5         | 4.00    |
| YG 2         | 18.6          | 2.00    | 56.0         | 2.00    | 68.5         | 2.00    |
| YG 3         | 69.8          | 0.00    | 30.4         | 0.00    | 19.7         | 0.00    |
| YG 4         | 9.3           | (13.50) | 0.0          | (13.50) | 1.3          | (13.50) |
| YG 5         | 0.0           | 19.33   | 0.0          | 19.33   | 0.0          | 19.33   |
| No. of head  | 43            |         | 125          |         | 77           |         |
| Base price   | 143.83        |         | 148.10       |         | 149.78       |         |

\*discount or premium with grid pricing

Profit or loss accounted for initial calf price, feed, yardage, veterinary, freight, brand inspection, beef check-off, ultrasound and carcass data collection costs. Initial calf price as price per 100 pounds, \$ =175.77703 – (0.10246 \* initial calf weight). Interest costs on cattle and feeding were not included in calculating profit or loss. Final carcass value was assessed using the actual grid pricing for the harvest group.

Overall, cattle feeding provided a \$33.68-per-head loss before interest expense was deducted. However, the top profit herd of calves returned \$110.80 per head while the bottom pen of calves with no death loss returned a \$67.79-per-head loss. The bottom pen of calves, with death loss included, returned a \$216.48-per-head loss.

The top five herds averaged \$61.84 per head profit. The average of the bottom five herds with no deaths lost \$61.65 per head. The five herds with death loss averaged a loss of \$172.84 per head (Table 3).

Correlations among profit and date of birth, harvest weight, average daily gain, weight per day of age, carcass backfat, carcass ribeye area, UDSA yield grade and marbling score were low (Table 4).

## Implications

Calf value is unknown until cattle are fed to finish. Feedlot performance is important for increased weight gain and heavier carcass weights. Exceptional average daily gains, weight per day of age and carcass characteristics, including marbling score, can be found in North Dakota beef herds. Feedout projects provide a source of information for cattle producers to learn about genetics, calf performance and cattle value.

## Citations

Hoppe, K.F., V.L.Anderson, H. Hughes and K. Alderin. 1997. Finishing North Dakota Calves in North Dakota or Kansas - Final Report. A Report on Agricultural Research and Extension in Central North Dakota. 38:7.

**Table 4. Correlations between profit and various production and carcass measurements.**

|                                  | Correlation coefficient |
|----------------------------------|-------------------------|
| Profit and Date of birth         | -0.492                  |
| Profit and Harvest Weight        | 0.414                   |
| Profit and Average Daily Gain    | 0.119                   |
| Profit and Weight per Day of Age | -0.128                  |
| Profit and Carcass Backfat       | 0.165                   |
| Profit and Carcass Ribeye Area   | 0.200                   |
| Profit and USDA Yield Grade      | 0.239                   |
| Profit and Marbling Score        | 0.196                   |

**Table 2. Feeding performance — 2007-2008 Eastern Dakota Cattle Feedout.**

| Herd               | Date of birth | Harvest Weight | Average Daily Gain | Weight Per Day of Age | Carcass Backfat | Carcass Ribeye Area | Carcass USDA Yield Grade | Carcass Marbling Score | Profit or Loss Per Head |
|--------------------|---------------|----------------|--------------------|-----------------------|-----------------|---------------------|--------------------------|------------------------|-------------------------|
| 1                  | 15-Feb-07     | 1,340.50       | 3.09               | 2.95                  | 0.36            | 14.00               | 2.15                     | 415.4                  | \$110.80                |
| 2                  | 13-Mar-07     | 1,241.68       | 2.79               | 2.84                  | 0.40            | 13.82               | 2.33                     | 410.0                  | \$67.42                 |
| 3                  | 21-Feb-07     | 1,233.39       | 2.76               | 2.80                  | 0.41            | 14.07               | 2.17                     | 443.3                  | \$57.00                 |
| 4                  | 15-Mar-07     | 1,408.66       | 3.62               | 3.17                  | 0.34            | 14.30               | 2.17                     | 380.0                  | \$48.52                 |
| 5                  | 17-Mar-07     | 1,130.15       | 3.02               | 2.55                  | 0.43            | 13.30               | 2.50                     | 436.7                  | \$25.43                 |
| 6                  | 30-Jan-07     | 1,221.13       | 3.23               | 2.63                  | 0.39            | 14.27               | 2.17                     | 376.7                  | \$23.55                 |
| 7                  | 17-Feb-07     | 1,266.30       | 3.18               | 2.85                  | 0.43            | 13.25               | 2.39                     | 441.1                  | \$21.06                 |
| 8                  | 22-Jan-07     | 1,273.19       | 3.41               | 2.74                  | 0.59            | 13.23               | 3.17                     | 513.3                  | \$19.90                 |
| 9                  | 2-Apr-07      | 1,227.24       | 3.49               | 2.87                  | 0.33            | 12.77               | 2.17                     | 428.3                  | \$12.53                 |
| 10                 | 14-Mar-07     | 1,247.64       | 2.73               | 2.93                  | 0.47            | 12.70               | 2.67                     | 376.7                  | \$9.88                  |
| 11                 | 1-Mar-07      | 1,223.03       | 3.24               | 2.78                  | 0.35            | 14.16               | 2.06                     | 420.0                  | \$(4.65)                |
| 12                 | 5-Mar-07      | 1,182.63       | 3.18               | 2.66                  | 0.34            | 13.17               | 2.15                     | 447.7                  | \$(10.48)               |
| 13                 | 8-Apr-07      | 1,190.00       | 3.20               | 2.84                  | 0.37            | 13.19               | 2.27                     | 431.3                  | \$(22.16)               |
| 14                 | 3-Mar-07      | 1,345.83       | 3.81               | 3.06                  | 0.53            | 12.72               | 2.83                     | 423.3                  | \$(41.51)               |
| 15                 | 15-Mar-07     | 1,127.88       | 3.01               | 2.67                  | 0.37            | 12.89               | 2.18                     | 453.6                  | \$(47.46)               |
| 16                 | 21-Feb-07     | 1,242.37       | 3.73               | 2.95                  | 0.64            | 12.73               | 3.17                     | 586.7                  | \$(51.37)               |
| 17                 | 19-Apr-07     | 1,161.66       | 3.42               | 3.02                  | 0.44            | 13.30               | 2.30                     | 407.0                  | \$(53.23)               |
| 18                 | 16-Mar-07     | 1,247.67       | 3.43               | 2.91                  | 0.36            | 13.57               | 2.17                     | 405.0                  | \$(54.14)               |
| 19                 | 30-Mar-07     | 1,277.97       | 2.97               | 3.04                  | 0.23            | 14.79               | 1.45                     | 332.7                  | \$(54.64)               |
| 20                 | 1-Apr-07      | 1,153.66       | 3.19               | 2.82                  | 0.45            | 12.70               | 2.50                     | 385.0                  | \$(58.22)               |
| 21                 | 24-Mar-07     | 1,111.78       | 3.54               | 2.72                  | 0.43            | 12.50               | 2.50                     | 455.0                  | \$(58.86)               |
| 22                 | 7-Apr-07      | 1,133.71       | 3.66               | 2.79                  | 0.32            | 12.68               | 2.29                     | 436.3                  | \$(60.54)               |
| 23                 | 26-Mar-07     | 1,160.51       | 3.10               | 2.99                  | 0.62            | 12.89               | 3.00                     | 508.9                  | \$(62.83)               |
| 24                 | 17-Apr-07     | 1,129.72       | 3.12               | 2.84                  | 0.34            | 12.78               | 2.08                     | 380.0                  | \$(67.79)               |
| 25                 | 16-Mar-07     |                |                    |                       |                 |                     |                          |                        | \$(133.72)              |
| 26                 | 29-Mar-07     | 1,195.38       | 2.82               | 3.03                  | 0.36            | 14.02               | 2.00                     | 412.0                  | \$(157.90)              |
| 27                 | 12-Apr-07     | 1,147.18       | 2.82               | 2.89                  | 0.29            | 12.82               | 1.80                     | 366.0                  | \$(183.24)              |
| 28                 | 16-Mar-07     | 1,239.31       | 2.85               | 2.82                  | 0.32            | 13.96               | 1.89                     | 350.0                  | \$(216.48)              |
| Mean               | 15-Mar-07     | 1,217.04       | 3.20               | 2.86                  | 0.40            | 13.35               | 2.32                     | 423.04                 | \$(33.68)               |
| Standard Deviation | 21.953        | 73.530         | 0.312              | 0.144                 | 0.098           | 0.643               | 0.393                    | 53.059                 | 74.848                  |
| Number             | 28            | 27             | 27                 | 27                    | 27              | 27                  | 27                       | 27                     | 28                      |

**Table 3. Feeding performance of top, middle and bottom five herds when sorted by profit.**

| Herd                                    | Date of Birth | Harvest Weight | Average Daily Gain | Weight Per Day of Age | Carcass Backfat | Carcass Ribeye Area | Carcass USDA Yield Grade | Carcass Marbling Score | Profit or Loss Per Head |
|---|---------------|----------------|--------------------|-----------------------|-----------------|---------------------|--------------------------|------------------------|-------------------------|
| Average - top 5 herds                   | 5-Mar-07      | 1,270.88       | 3.06               | 2.86                  | 0.39            | 13.90               | 2.26                     | 417.08                 | \$61.84                 |
| Average - middle 5 herds                | 12-Mar-07     | 1,237.83       | 3.23               | 2.85                  | 0.41            | 13.19               | 2.40                     | 419.81                 | \$(13.78)               |
| Average - bottom 5 herds with no deaths | 3-Apr-07      | 1,137.88       | 3.32               | 2.83                  | 0.43            | 12.71               | 2.47                     | 433.03                 | \$(61.65)               |
| Average - bottom 5 herds with deaths    | 26-Mar-07     | 1,193.96       | 2.83               | 2.91                  | 0.32            | 13.60               | 1.90                     | 376.00                 | \$(172.84)              |

# Effects of feeding strategy on market cow performance, carcass quality and economics\*

M.M. Thompson<sup>1</sup>, C.S. Schauer<sup>1</sup>, R.J. Maddock<sup>2</sup> and C.L. Wright<sup>3</sup>

*The objective of this study was to investigate the effects of feeding strategy on cow feedlot performance, carcass traits and economics. Despite cows consuming less feed and lower labor costs, cows on self-fed diets had the highest feed cost of gain. Although self-fed diets can improve market cow quality, other low-cost alternatives require further investigation.*

## Summary

Forty-eight cull (market) cows were blocked by weight and body condition to investigate the effects of feeding strategy on feedlot performance, carcass traits and economics. Diets evaluated were (1) corn-mixed hay (HAY), (2) barley-barley silage (SILAGE) and (3) a self-fed ground diet using a controlled intake system (LIMIT). All diets were formulated to provide 60 megacalories per pound (Mcal/lb) of net energy for gain (NE<sub>g</sub>) and 11.5 percent crude protein (CP) using mixed hay, barley silage and a commercial supplement containing soy hulls as roughage sources for HAY, SILAGE and LIMIT, respectively.

After a 104-day feeding period, 14 cows were sold at auction locally to evaluate market prices for fattened cull cows. The remaining cows were harvested at Dakota Premium Foods LLC, South St. Paul, Minn., with individual carcass data collected. HAY and SILAGE cows gained faster ( $P < 0.01$ ) because LIMIT cows acclimated slowly to their diet the first 46 days of study, resulting in lower dry-matter intake (DMI), average daily gain (ADG) and gain efficiencies (G:F) for LIMIT cows ( $P < 0.02$ ). LIMIT cows had higher feed costs than HAY and SILAGE cows ( $P = 0.02$ ). Despite similar final body condition scores ( $P = 0.19$ ), LIMIT cows gained the least ( $P = 0.04$ ). Carcass traits and total cow value were similar across treatments for harvested cows ( $P = 0.10$ ). HAY cows had the lowest breakeven and

greatest return for harvested cows ( $P \leq 0.02$ ); however, breakevens and returns for sold cows did not differ across treatment ( $P = 0.15$ ). Although self-fed diets can improve market cow quality, other low-cost alternatives require further investigation.

## Introduction

The sale of market cows (cull cows) can contribute a considerable portion of income (15 percent to 30 percent) to the annual receipts of cow-calf producers (Feuz, 2006). Six million to 8 million market cows are slaughtered annually, providing a sizeable supply of muscle cuts to the packing industry (Stalcup, 2008). Generally, spring calving market cows are sold in the fall (following weaning and pregnancy checking) at a time when the cow supply is large and economic returns are low. Often, cow-calf producers give little forethought to adding value to market cows before culling. One method of enhancing market cow value is to feed the cows for a short time (60 to 100 days) and then sell the cows when market prices are seasonally higher (Strohbehn et al., 2004; Strohbehn and Sellers, 2002). As well as increasing market value, a feeding period enables cow-calf producers to improve cow carcass quality (Wright, 2005).

Moreover, little research has examined the use of self-feeding protocols as a system of adding value to market cows. As volatility continues in the

<sup>1</sup>Hettinger Research Extension Center, North Dakota State University, Hettinger, ND 58639

<sup>2</sup>Department of Animal Sciences, North Dakota State University, Fargo, ND 58105

<sup>3</sup>Department of Animal and Range Sciences, South Dakota State University, Brookings, SD 57007

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feed ingredient markets and fuel and other production input expenses increase, re-evaluation of market cow feeding strategies and economic profitability is crucial (Niemela et al., 2008). Our study objective was to investigate the effects of feeding strategy on cow feedlot performance, carcass characteristics and economics. Our hypothesis was that the three feeding strategies would have similar performance and carcass quality, but the self-fed system would have lower feed and labor costs associated with it as compared with the other two systems.

## Materials and Methods

The NDSU Animal Care and Use Committee approved all protocols. Sixty-eight Angus cross and Hereford market cows were purchased locally during a two-week period (Oct. 22 and 29, 2007). After purchase, cows were delivered to the NDSU Hettinger Research Extension Center. On day 0 and 1, purchased cows were weighed, had their body condition scored on a scale of 1 to 9 (body condition score [BCS], Herd and Sprott, 1986); and were evaluated for pregnancy status, temperament and overall health. From this group, 48 nonpregnant cows were selected as study subjects. Cows were vaccinated for respiratory and clostridial diseases, dewormed and implanted (Finaplex H, Intervet, Millsboro, Del.) on day 1. Cows were stratified by weight (body weight [BW] =  $1,313 \pm 14.7$  pounds) and BCS ( $5.71 \pm 0.07$ ) and allotted to one of 12 pens (four cows/pen). Pens were assigned randomly to one of three treatments: corn-mixed hay (HAY), barley-barley silage (SILAGE) and a self-fed ground diet using a controlled intake system (LIMIT). Diets were formulated to provide 60 Mcals/lb NE<sub>g</sub> and 11.5 percent CP using ground mixed hay, barley silage and a commercial supplement containing soy hulls as roughage sources for HAY, SILAGE and LIMIT respectively (Table 1).

Alfalfa haylage and soybean meal (47.5 percent CP) were included in the HAY diet to prevent ration separation and increase CP level. Ground hay was added to the SILAGE diet to increase ration dry matter (DM). Four rations of increasing energy density (data not reported) were fed to HAY and SILAGE cows during the first 40 days to acclimate cows to high-grain finishing diets. Fence line feed bunks were read daily at 7 a.m. and slick bunk management was used to determine individual pen daily feed allotment. HAY and SILAGE cows were fed once daily at 9 a.m. Purina Mills developed the feeding protocol used for the LIMIT cows. Creep feeders (self-feeders) were means of diet delivery for LIMIT cows. LIMIT cows had continual access to self-feeders containing respective diets (Table 1); LIMIT cows were fed small amounts of baled grass hay daily (6.4 pounds/

cow; as fed). LIMIT diets were ground and feeders filled on day 0, 8, 22, 36, 42, 45, 47, 53, 63 and 74. All cows had free access to water in ice-free automatic fence line water fountains and white salt blocks. To prevent estrus, MGA pellets were added to all diets.

Due to deteriorating pen conditions because of inclement weather, all cows were removed from feedlot pens on day 76, commingled into one group and placed into a larger pen. From day 76 to 103, cows were fed a mixed ration at 2.6 percent BW (based on day 75 BW) containing 25 percent barley silage, 25 percent ground mixed hay, 22.5 percent whole barley, 22.6 percent cracked corn, 1.9 percent finishing supplement, 2.5 percent MGA pellets and 1.9 percent calcium carbonate (DM basis, 13.7 percent CP, 52 Mcal/lb NE<sub>g</sub>) for the last 28 days prior to

**Table 1. Dietary ingredient and nutrient concentration of HAY, SILAGE and LIMIT diets.**

| Item                                | Hay   | Silage | Limit                   |         |                     |
|-------------------------------------|-------|--------|-------------------------|---------|---------------------|
|                                     |       |        | Accuration <sup>a</sup> |         | Impact <sup>b</sup> |
|                                     |       |        | d 0-21                  | d 22-46 | d 47-75             |
| Ingredient, % DM                    |       |        |                         |         |                     |
| Alfalfa haylage                     | 8.5   | -      | -                       | -       | -                   |
| Barley silage                       | -     | 16.1   | -                       | -       | -                   |
| Calcium carbonate                   | 0.7   | 0.7    | -                       | -       | -                   |
| Whole barley                        | -     | 67.2   | -                       | -       | -                   |
| Cracked corn                        | 71.4  | -      | 34.8                    | 60.8    | 78.5                |
| Finish supplement <sup>c</sup>      | 2.0   | 1.8    | -                       | -       | -                   |
| Purina supplement                   | -     | -      | 52.1                    | 26.1    | 8.7                 |
| MGA pellets <sup>d</sup>            | 2.6   | 2.4    | 2.8                     | 2.8     | 2.8                 |
| Ground mixed hay <sup>e</sup>       | 12.7  | 11.8   | -                       | -       | -                   |
| Soybean meal (47.5% CP)             | 2.1   | -      | -                       | -       | -                   |
| Grass hay                           | -     | -      | 10.0                    | 10.0    | 10.0                |
| 12:12 mineral                       | -     | -      | 0.3                     | 0.3     | -                   |
| Nutrient concentration <sup>f</sup> |       |        |                         |         |                     |
| % DM                                | 76.92 | 69.22  | 88.19                   | 87.52   | 85.2                |
| CP, % DM                            | 11.7  | 14.5   | 23.7                    | 22.9    | 14.8                |
| NE <sub>m</sub> , Mcal/lb. DM       | 0.82  | 0.80   | 0.92                    | 0.93    | 0.87                |
| NE <sub>g</sub> , Mcal/lb. DM       | 0.55  | 0.54   | 0.61                    | 0.62    | 0.58                |
| Ca:P                                | 2.76  | 2.81   | 1.56                    | 1.50    | 1.62                |

<sup>a</sup> Purina supplement contained 65 mg/lb. Monensin sodium.

<sup>b</sup> Purina supplement contained 113.5 mg/lb. Monensin sodium and 45 mg/lb. Tylosin phosphate.

<sup>c</sup> Supplement contained 500 mg/lb. Monensin sodium.

<sup>d</sup> Supplement contained 0.00011% Melengestrol Acetate.

<sup>e</sup> Mixed hay composed of equal parts barley and alfalfa-grass hays.

<sup>f</sup> Analytical results are from composited samples.

harvest. The roughage-based diet was fed because of concerns about possible cow lameness and cows going down during the long transport to harvest.

Cows were weighed and had their body condition scored on day 0, 1, 28, 45, 46, 74, 75, 102 and 103. Initial and final weights were determined by averaging two-day unshrunk weights. HAY and SILAGE diet samples were collected on day 6, 22, 43, 60 and 74. LIMIT diet samples were collected on day 1, 6, 36, 60, 63 and 74. Diet samples from the commingled group were collected on day 80, 90 and 100. Diet samples were composited by treatment and analyzed by a commercial laboratory (Midwest Laboratories, Omaha, Neb.) for nutrient analysis. After the 104-day feeding period, 14 cows were sold at auction locally (n = 4 for SILAGE and n = 5 for HAY and LIMIT, respectively) to evaluate local market prices (Lemmon Livestock Inc., Lemmon, S.D., Feb. 13, 2008) for fattened cull cows. The remaining cows (n = 33) were harvested at Dakota Premium Foods LLC, South St. Paul, Minn., on day 104 and individual carcass data was collected following a 24-hour chill.

Economic values for feedstuffs and other service fees were obtained from purchased costs, local cash grain bids and the U.S. Department of Agriculture National Agricultural Statistics Service's North Dakota monthly commodity prices ([www.nass.usda.gov/nd](http://www.nass.usda.gov/nd)). Breakeven and closeout information was calculated using the NDSU Extension CalfWEB closeout analysis program ([www.chaps2000.com/calfweb/closeout.asp](http://www.chaps2000.com/calfweb/closeout.asp)). Cow performance, carcass traits and economic data were analyzed as a completely randomized design with the pen serving as the experimental unit. Carcass data was analyzed similarly, with missing data points from auctioned cows not included in the data set, but with the pen still serving

as the experimental unit. Treatment means are separated by least square means following a protected F-test ( $P < 0.05$ ).

## Results and Discussion

Cow feedlot performance is shown in Table 2. One cow (HAY) was removed from the study because of founder (day 57). All performance data from the removed cow was deleted from subsequent performance analyses. Additionally, two cows were treated for foot rot (LIMIT and HAY, day 49 and 55, respectively). Veterinary medicine

costs did not differ between treatments and averaged \$12.15 ± 0.59 per cow ( $P = 0.69$ ; Table 2). In general, dry-matter intakes for market cows are greater compared with calf-feds or yearling DMI.

Calf-fed DMI typically range from 20 to 24 pounds/day, yearlings from 23 to 28 pounds/day DMI and mature cows from 28 to 45 pounds/day DMI, depending on respective body weights. In this study, HAY and SILAGE cows gained faster ( $P < 0.01$ ) because LIMIT cows acclimated slowly to their diet the first 46 days of study,

**Table 2. Influence of market cow feeding strategy on feedlot performance and associated costs.**

| Item                               | HAY <sup>a</sup>   | SILAGE <sup>b</sup> | LIMIT <sup>c</sup> | SEM <sup>d</sup> | P-value <sup>e</sup> |
|------------------------------------|--------------------|---------------------|--------------------|------------------|----------------------|
| No. head                           | 16                 | 15                  | 16                 | -                | -                    |
| No. pens                           | 4                  | 4                   | 4                  | -                | -                    |
| Initial BW, lb.                    | 1324               | 1300                | 1315               | 14.74            | 0.55                 |
| Initial BCS                        | 5.68               | 5.71                | 5.75               | 0.07             | 0.74                 |
| Period 1, day 0-46                 |                    |                     |                    |                  |                      |
| DMI, lb./d                         | 38 <sup>f</sup>    | 28 <sup>g</sup>     | 25.6 <sup>h</sup>  | 0.59             | < 0.001              |
| 46-day gain, lb.                   | 185.8 <sup>f</sup> | 153.5 <sup>f</sup>  | 40.8 <sup>g</sup>  | 27.2             | 0.01                 |
| ADG, lb./d                         | 4.09 <sup>f</sup>  | 3.54 <sup>f</sup>   | 0.89 <sup>g</sup>  | 0.60             | 0.01                 |
| G:F                                | 0.11 <sup>f</sup>  | 0.13 <sup>f</sup>   | 0.03 <sup>g</sup>  | 0.02             | 0.02                 |
| Feed cost/lb gain, \$/lb.          | 0.79               | 0.83                | 2.21               | 1.44             | 0.74                 |
| Period 2, day 47-75                |                    |                     |                    |                  |                      |
| DMI, lb./d                         | 40                 | 37.9                | 37.8               | 1.58             | 0.56                 |
| 29-day gain, lb.                   | 120.3              | 157.5               | 161.8              | 14.4             | 0.14                 |
| ADG, lb./d                         | 4.14               | 5.42                | 5.58               | 0.50             | 0.14                 |
| G:F                                | 0.10               | 0.14                | 0.15               | 0.01             | 0.09                 |
| Feed cost/lb. gain, \$/lb.         | 0.82               | 0.71                | 0.70               | 0.08             | 0.52                 |
| Final, day 0-75                    |                    |                     |                    |                  |                      |
| DMI, lb./d                         | 38.8 <sup>f</sup>  | 33.5 <sup>g</sup>   | 31 <sup>g</sup>    | 1.06             | 0.002                |
| 75-day gain, lb.                   | 308.3 <sup>f</sup> | 281 <sup>f</sup>    | 195.3 <sup>g</sup> | 26.8             | 0.04                 |
| ADG, lb./d                         | 4.11 <sup>f</sup>  | 3.75 <sup>f,g</sup> | 2.61 <sup>g</sup>  | 0.36             | 0.04                 |
| G:F                                | 0.11               | 0.11                | 0.08               | 0.01             | 0.13                 |
| Feed cost/lb. gain, \$/lb.         | 0.79 <sup>g</sup>  | 0.80 <sup>g</sup>   | 1.72 <sup>f</sup>  | 0.15             | 0.002                |
| Final BW, lb.                      | 1629.3             | 1600.5              | 1517.5             | 27.8             | 0.047                |
| Final BCS (1-9)                    | 7.45               | 7.48                | 7.10               | 0.16             | 0.19                 |
| Commingled period, day 76-103      |                    |                     |                    |                  |                      |
| 28-day gain, lb.                   | 98.8               | 124.8               | 155.5              | -                | -                    |
| ADG, lb./d                         | 3.40               | 4.30                | 5.35               | -                | -                    |
| Yardage costs, \$/cow <sup>h</sup> | 36.75 <sup>f</sup> | 36.75 <sup>f</sup>  | 29.15 <sup>g</sup> | -                | < 0.001              |
| Veterinary medicine costs, \$/cow  | 11.88              | 12.59               | 11.99              | 0.59             | 0.69                 |

<sup>a</sup> HAY: Hay-based finishing diet consisted of ground mixed hay, cracked corn, alfalfa haylage, finish supplement, soybean meal, MGA pellets and calcium carbonate.

<sup>b</sup> SILAGE: Silage-based finishing diet consisted of barley silage, cracked barley, ground mixed hay, finish supplement, MGA pellets and calcium carbonate.

<sup>c</sup> LIMIT: Self-fed finishing diet, offered ad-libitum via self-feeders placed in pens.

<sup>d</sup> Standard error of mean; n = 4 observations per treatment.

<sup>e</sup> P-value for protected F test.

<sup>f, g, h</sup> Means with different subscripts differ ( $P < 0.05$ ).

resulting in lower DMI, ADG and feed efficiencies (gain:feed ratios, G:F) for LIMIT cows ( $P < 0.02$ ). LIMIT cows' DMI and ADG increased when the cows consumed the final self-fed diet during Period 2 (Table 2). At the end of 75 days, LIMIT and SILAGE cows had similar DMI, but differed from HAY cows ( $P = 0.007$ ). Despite final G:F being similar across treatments ( $P = 0.13$ ), LIMIT cows had the lowest DMI and ADG and the highest feed cost/lb. of gain ( $P < 0.02$ ). Feed costs/lb. gained were similar for HAY and SILAGE cows ( $P = 0.02$ ). Although final BCS were similar across treatments ( $P = 0.19$ ), HAY cows were the heaviest, SILAGE cows intermediate and LIMIT cows the lightest before commingling ( $P = 0.02$ ).

Yardage costs were 20 percent lower for LIMIT cows as compared with HAY and SILAGE cows ( $P < 0.001$ ). Yardage charges were determined by surveying cattle feeders about yardage fees they charged their commercial feeding clients. Yardage fees were 25 cents per head per day for LIMIT cows and 35 cents per head per day for HAY and SILAGE cows. The use of self-feeders decreased labor and equipment needs during the 75-day period as compared with more traditional feeding methods (totally mixed rations fed by a feeder wagon).

Cow weight gain and ADG during the commingled period (day 76 to 103) is reported in Table 2. Because of combining all pens into one large group, treatment effects could not be separated statistically during the commingled period. As a result, weight gain data from the commingled period is reported to illustrate the continued weight gain all cows experienced during the 28 days preceding harvest.

Carcass traits and total cow value were similar across treatments for harvested cows ( $P = 0.10$ ; Table 3). This may be

attributed to greater compensatory gain and DMI exhibited by LIMIT cows during the commingled period than is shown by the weight gain data before harvest (day 76 to 103, Table 2). Cows sent to the commercial abattoir received the same price at harvest (\$1.08/pound of hot carcass weight). The effect of feeding strategy on auctioned cows and closeout returns is reported in Table 3. Initial average value for the cull cows used in this study was \$0.455/pound or \$596.70/head. Feeding these cows for an additional 104 days increased the average cow value to \$1,009.31/head  $\pm$  \$16.26 for harvested cows, with no difference among treatments ( $P = 0.14$ ). Additionally, cows sold at

auction had increased value, averaging \$958.18/head, with no difference between treatments ( $P = 0.29$ ).

Sale cow BW was similar at the local auction on sale day ( $P = 0.08$ ). Although cow values were increased for both auctioned and harvested cows, these increased values do not reflect the added expense of feeding these cows for an additional 104 days. HAY cows had the lowest breakeven and greatest return for harvested cows ( $P \leq 0.02$ ); however, the breakevens and economic returns for sold cows did not differ across treatments ( $P = 0.15$ ). Cows sold at auction received similar market prices across treatments, with cows averaging \$0.595/pound ( $P = 0.34$ ).

**Table 3. Influence of market cow feeding strategy on carcass traits and economics.**

| Item                               | HAY <sup>a</sup>    | SILAGE <sup>b</sup>   | LIMIT <sup>c</sup> | SEM <sup>d</sup> | P-value <sup>e</sup> |
|------------------------------------|---------------------|-----------------------|--------------------|------------------|----------------------|
| Harvested cows                     |                     |                       |                    |                  |                      |
| Hot carcass weight, lb.            | 961.5               | 925.3                 | 917.3              | 15.1             | 0.14                 |
| Dressing %                         | 54                  | 53                    | 54                 | 0.78             | 0.88                 |
| Lean maturity <sup>f</sup>         | 448                 | 453                   | 445                | 19.61            | 0.96                 |
| Skeletal maturity <sup>f</sup>     | 441                 | 477                   | 446                | 16.09            | 0.29                 |
| Marbling score <sup>g</sup>        | 398                 | 390                   | 422                | 21.81            | 0.58                 |
| 12th rib fat thickness, in.        | 0.56                | 0.74                  | 0.59               | 0.05             | 0.10                 |
| Longissimus area, in. <sup>2</sup> | 13.7                | 12.5                  | 12                 | 0.7              | 0.25                 |
| Muscling score <sup>h</sup>        | 2.75                | 3.25                  | 3.75               | 0.34             | 0.18                 |
| Fat color <sup>i</sup>             | 2.75                | 3.25                  | 2.50               | 0.26             | 0.18                 |
| Lean color <sup>j</sup>            | 5.25                | 6.0                   | 5.50               | 0.40             | 0.44                 |
| Total cow value, \$                | 1,038.33            | 999.27                | 990.32             | 16.26            | 0.14                 |
| Auctioned cows                     |                     |                       |                    |                  |                      |
| Sale BW, lb.                       | 1656.3              | 1776.3                | 1584.5             | 52.8             | 0.08                 |
| Sale price, \$/lb.                 | 0.595               | 0.603                 | 0.588              | 0.64             | 0.34                 |
| Total cow value, \$                | 962.74              | 1005.51               | 906.29             | 41.78            | 0.29                 |
| Breakevens                         |                     |                       |                    |                  |                      |
| Harvested cows, \$/lb.             | 0.53 <sup>l</sup>   | 0.54 <sup>k,1</sup>   | 0.56 <sup>k</sup>  | 0.007            | 0.03                 |
| Auctioned cows, \$/lb.             | 0.52                | 0.50                  | 0.56               | 0.02             | 0.11                 |
| Closeouts, profit or loss          |                     |                       |                    |                  |                      |
| Harvested cows, \$/head            | 155.34 <sup>k</sup> | 125.22 <sup>k,1</sup> | 94.92 <sup>l</sup> | 13.35            | 0.03                 |
| Auctioned cows, \$/head            | 122.41              | 175.61                | 53.62              | 40.09            | 0.15                 |

<sup>a</sup>HAY: Hay-based finishing diet consisted of ground mixed hay, cracked corn, alfalfa haylage, finish supplement, soybean meal, MGA pellets and calcium carbonate.

<sup>b</sup>SILAGE: Silage-based finishing diet consisted of barley silage, cracked barley, ground mixed hay, finish supplement, MGA pellets and calcium carbonate.

<sup>c</sup>LIMIT: Self-fed finishing diet, offered ad-libitum via self-feeders placed in pens.

<sup>d</sup>Standard error of mean; n = 4 observations per treatment.

<sup>e</sup>P-value for protected F test.

<sup>f</sup>A = 100 to 199, B = 200 to 299, C = 300 to 399, D = 400 to 499 and E = 500 to 599.

<sup>g</sup>Slight = 300 to 399 and Small = 400 to 499.

<sup>h</sup>Thin = 1, Average = 3 and Thick = 5.

<sup>i</sup>Pure white = 1, Yellow = 5.

<sup>j</sup>Light red = 1, Cherry red = 4 and Very dark red = 8.

<sup>k,l</sup>Means with different subscripts differ ( $P < 0.05$ ).

## Implications

Feeding hay-based, silage-based or self-fed rations for a short time (during late fall-early winter) resulted in a net profit for feeding market cows. Despite the increased dietary adjustment time, LIMIT cows gained more efficiently when consuming their final self-fed diet. Although LIMIT cows consumed less feed and had lower labor costs, feed cost of gain was highest for this group. Potential economic returns by feeding market cows will be highly dependent on several factors: availability of local resources, initial cow body condition, feed costs and availability, days on feed and final carcass characteristics. Self-feeders are a viable alternative system of feeding and improving market cow value. Although self-fed diets can improve market cow quality, other low-cost alternatives require further investigation.

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# Factors influencing price of North Dakota, South Dakota and Montana feeder calves

J.L. Leupp<sup>1</sup>, G.P. Lardy<sup>1</sup>, R. Daly<sup>2</sup>, C.L. Wright<sup>3</sup> and J.A. Paterson<sup>4</sup>

*Data were collected from three sale barns in North Dakota and two sale barns each in South Dakota and Montana during late autumn and midwinter to determine factors influencing the sale price of feeder calves from these auction markets. Selling calves in larger lot sizes with vaccinations was economically advantageous.*

## Summary

Our objective was to determine factors influencing the sale price of feeder calves from North Dakota, South Dakota and Montana auction markets. Data were collected at three auction markets in North Dakota and two auction markets each in South Dakota and Montana in fall 2007 (59,855 calves; 531 ± 2 pounds of average weight; three sales per market) and winter 2008 (39,454 calves; 625 ± 5 pounds of average weight; three sales per market). Data were collected during the same weeks in each state to reduce confounding effects of fluctuations in market patterns. The following data were collected for each lot of calves sold: lot size, sex, weight, breed description, vaccination history, implant status and natural program qualification.

In the fall, producers who sold calves in lot sizes of 21 or more head received greater ( $P < 0.001$ ) prices when compared with producers who sold calves in lots of 20 or fewer head. Calves sold in lot sizes of 11 to 20 were priced greater ( $P \leq 0.04$ ) than calves sold in lot sizes of 10 or fewer. Lot sizes of six to 10 received greater ( $P < 0.001$ ) prices than lot sizes of five or fewer head.

The price for steers was \$9.68/hundredweight (cwt) greater ( $P < 0.001$ ) than for heifers. The price for black cattle was greater ( $P < 0.001$ ) than prices received for mixed-color groups, red or white cattle. Mixed-

color and red cattle were priced similarly ( $P = 0.55$ ); however, mixed-color cattle tended ( $P = 0.06$ ) to sell for greater prices than white cattle. Red and white cattle were priced similarly ( $P = 0.17$ ). Calves sold with a seven-way clostridial, four-way viral and Pasteurella vaccines were priced greater ( $P < 0.001$ ) than calves vaccinated with a four-way viral vaccine only or no vaccination history. Price received for calves vaccinated with a four-way viral vaccine was greater ( $P < 0.001$ ) than calves with no vaccination history.

No differences ( $P \geq 0.11$ ) in price were observed for implant status or natural program-qualified calves. In winter, the price received for lot sizes of 21 or more and 11 to 20 were priced similarly ( $P = 0.17$ ) but were greater ( $P \leq 0.04$ ) than lots of 10 or fewer head. Lot sizes of six to 10 were priced greater ( $P < 0.001$ ) than lots of five or fewer head. The price for steers was \$8.99/cwt greater ( $P < 0.001$ ) than heifers. The price for black cattle was greater ( $P < 0.001$ ) than all other colors of cattle. Mixed and red cattle were priced similarly ( $P = 0.61$ ) but greater than ( $P \leq 0.05$ ) white cattle. Vaccinated calves brought a greater ( $P < 0.001$ ) price than calves with no vaccination history. No differences ( $P \geq 0.24$ ) in price were observed for implant status or natural program-qualified calves. Data suggest feeder calf price is dependent on multiple factors. Selling calves in larger lot sizes with vaccinations is economically advantageous.

<sup>1</sup> Department of Animal Sciences, North Dakota State University, Fargo, ND 58105

<sup>2</sup> Department of Veterinary Science, South Dakota State University, Brookings, SD 57007

<sup>3</sup> Department of Animal and Range Sciences, South Dakota State University, Brookings, SD 57007

<sup>4</sup> Department of Animal and Range Sciences, Montana State University, Bozeman, MT 59717

## Introduction

Feeder calf prices are dependent on multiple factors. Many of these factors are affected by environmental conditions, such as feed prices, slaughter cattle prices and weather conditions (Schroeder et al., 1988). Other factors, such as lot sizes, calf weight, vaccination programs and season of the year, can be controlled by the producer when calves are marketed (Schroeder et al., 1988; King and Seeger, 2004a,b).

Calves marketed in larger lot sizes receive premiums, compared with calves sold in smaller lot sizes (Barham and Troxel, 2007). Premiums may be paid for larger lot sizes because they facilitate filling truckloads and cattle originate from fewer sources.

Calves in value-added programs sell for greater prices, compared with unweaned, unvaccinated calves (King and Seeger, 2004a,b; Corah et al., 2006). The price advantage for calves in value-added programs has been increasing in recent years (King and Seeger, 2004b).

Little quantitative information exists on factors influencing price of North Dakota, South Dakota and Montana feeder calves. Because prior management may affect calf prices received in the marketplace, informing producers of these factors is important for them to make informed decisions. Therefore, the objectives of this study were to determine factors influencing the sale price of feeder calves from North Dakota, South Dakota and Montana auction markets.

## Materials and Methods

Data were collected from three sale barns in North Dakota and two sale barns each in South Dakota and Montana (seven sale barns total) during the weeks of Oct. 29, Nov. 5 and Nov. 12, 2007 (fall), when

most calves sold were freshly weaned. The three auction markets in North Dakota were Napoleon Livestock, Napoleon; Kist Livestock, Mandan; and Stockmen's Livestock, Dickinson. The two auction markets in South Dakota were Faith Livestock, Faith; and Philip Livestock Auction, Philip. The two auction markets in Montana were PAYS Auction Yard, Billings; and Miles City Livestock Commission Co., Miles City. Data were collected at the same auction markets during the weeks of Jan. 7, Jan. 14, and Jan. 21, 2008 (winter). University representatives were present at each sale and collected the following for each lot of calves sold: lot size, sex, weight, hide color, health programs, vaccination history, use of

deworming products, implant status, natural program qualification, source and age verification status, and beef quality assurance (BQA) status.

Lot sizes were categorized into groups of 21 or more calves, 11 to 20 calves, six to 10 calves and five or fewer calves. Lots of calves sold were split into four color categories. Categories used for color were black, red, white and mixed-color pens. Lots were categorized based on 75 percent of one lot having a predominant color. For example, a lot having four black calves and one red calf would be categorized as a black lot. A lot having two black calves and three red calves would be categorized as a mixed-color lot. Three

**Table 1. Factors influencing price of North Dakota, South Dakota and Montana calves during fall 2007.**

| Factor                       | Number of lots | Lot price <sup>1</sup> | Price premium <sup>2</sup> | P-value |
|------------------------------|----------------|------------------------|----------------------------|---------|
| Lot size                     |                |                        |                            | <0.001  |
| ≥ 21                         | 745            | 114.95 <sup>a</sup>    | 6.32                       |         |
| 11–20                        | 819            | 113.44 <sup>b</sup>    | 4.81                       |         |
| 6–10                         | 1,007          | 112.65 <sup>c</sup>    | 4.02                       |         |
| ≤ 5                          | 2,789          | 108.63 <sup>d</sup>    | 0.00                       |         |
| Calf sex                     |                |                        |                            | <0.001  |
| Steers                       | 2,815          | 117.26 <sup>a</sup>    | 9.68                       |         |
| Heifers                      | 2,545          | 107.58 <sup>b</sup>    | 0.00                       |         |
| Color                        |                |                        |                            | <0.001  |
| Black, BWF <sup>3</sup>      | 3,369          | 114.20 <sup>a</sup>    | 2.90                       |         |
| Mixed                        | 745            | 112.21 <sup>b</sup>    | 0.91                       |         |
| Red, RWF <sup>4</sup>        | 757            | 111.96 <sup>b</sup>    | 0.66                       |         |
| White                        | 489            | 111.30 <sup>b</sup>    | 0.00                       |         |
| Vaccinations                 |                |                        |                            | <0.001  |
| 741 <sup>5</sup>             | 1,515          | 113.93 <sup>a</sup>    | 3.36                       |         |
| 4-way viral                  | 1,291          | 112.76 <sup>b</sup>    | 2.19                       |         |
| No vaccinations <sup>6</sup> | 2,554          | 110.57 <sup>c</sup>    | 0.00                       |         |
| Natural                      |                |                        |                            | 0.11    |
| Yes                          | 478            | 112.74                 | 0.64                       |         |
| No                           | 4,882          | 112.10                 | 0.00                       |         |
| Implants                     |                |                        |                            | 0.45    |
| Yes                          | 81             | 112.78                 | 0.72                       |         |
| No                           | 5,279          | 112.06                 | 0.00                       |         |
| Base weight <sup>7</sup>     | 5,360          |                        | -0.071                     | <0.001  |
| Base weight (quadratic)      | 5,360          |                        | 0.0001                     | <0.001  |

<sup>1</sup>Different superscripts within factor differ at  $P \leq 0.05$ .

<sup>2</sup>Price/hundred pounds.

<sup>3</sup>BWF = black, white face.

<sup>4</sup>RWF = red, white face.

<sup>5</sup>741 = 7-way clostridial plus 4-way viral plus Pasteurella

<sup>6</sup>No vaccination history, but may have 7-way clostridial.

<sup>7</sup>Mean base weight of all lots (531 lb) – base weight of each lot.

categories for vaccination status were used: 1) calves receiving a seven-way clostridial vaccination plus four-way viral vaccination plus *Pasteurella* vaccination (741 vaccination program), 2) four-way viral vaccination only or 3) calves with no vaccination history or having only a seven-way clostridial vaccination.

## Results

Data are presented as fall sales (October and November 2007; Table 1) and winter sales (January 2008; Table 2).

### Fall Sales

During fall 2007, 59,855 beef calves were sold in 5,360 lots (Table 1). The

average weight was 531 pounds, with a price slide of \$7.10/cwt.

Lot size affected ( $P < 0.001$ ) calf price. Calves sold in lot sizes of 21 or more calves were worth \$114.95/cwt, which was greater ( $P < 0.001$ ) than lot sizes of 11 or fewer head. Calves sold in lot sizes of 11 to 20 were priced greater ( $P = 0.04$ ) than lot sizes of six to 10 (\$113.44 vs. \$112.65/cwt, respectively). Calves sold in lot sizes of five or fewer sold for less ( $P < 0.001$ ; \$108.63/cwt) than larger lot sizes.

As expected, calf sex influenced ( $P < 0.001$ ) sale price. Prices for steer calves were greater ( $P < 0.001$ ) than prices for heifer calves (\$117.26/cwt vs. \$107.58/cwt, respectively).

An effect ( $P \leq 0.001$ ) of color was observed in the fall. Black cattle sold for \$114.20/cwt, which was more than ( $P < 0.001$ ) for the other colors of cattle. The price for black cattle was greater ( $P < 0.001$ ) than prices received for mixed, red or white cattle. Mixed-color and red cattle were priced similarly ( $P = 0.55$ ; \$112.09/cwt); however, mixed-color tended ( $P = 0.06$ ) to sell for greater prices than white cattle (\$112.21 vs. \$111.30/cwt, respectively). Red and white cattle were priced similarly ( $P = 0.17$ ) and averaged \$111.63/cwt. An effect ( $P < 0.001$ ) of vaccinations was observed for calves sold in the fall. Calves vaccinated with the 741 vaccination program were priced greater ( $P < 0.001$ ) than other vaccinated or nonvaccinated calves. Producers who marketed calves with a four-way viral vaccine received greater ( $P < 0.001$ ) prices than producers who marketed calves with no vaccination history (\$112.76 vs. \$110.57/cwt, respectively).

In the fall, prices did not differ ( $P = 0.11$ ) for calves that qualified for a natural program. Similarly, implant status did not affect ( $P = 0.45$ ) prices producers received in the marketplace. Insufficient lots sold as source and age verified and BQA certified in the fall which prevented determination of the value of those attributes.

### Winter Sales

In winter 2008, 39,454 calves were sold in 3,902 lots (Table 2). The average weight was 625 pounds, with a price slide of \$6.20/cwt.

Lot size had an effect ( $P < 0.001$ ) on calf price during the winter. Calves sold in large lot sizes of 21 or more and 11 to 20 were priced similarly ( $P = 0.17$ ) but greater than smaller lot sizes (six or fewer head). Calves sold in lot sizes of six to 10 were priced greater ( $P < 0.001$ ) than calves sold in lot sizes of five or fewer head (\$100.81 vs. \$97.29/cwt, respectively).

**Table 2. Factors influencing price of North Dakota, South Dakota and Montana calves during winter 2008.**

| Factor                       | Number of lots | Lot price <sup>1</sup> | Price premium <sup>2</sup> | P-value |
|------------------------------|----------------|------------------------|----------------------------|---------|
| Lot size                     |                |                        |                            | <0.001  |
| ≥ 21                         | 514            | 102.17 <sup>a</sup>    | 4.88                       |         |
| 11–20                        | 521            | 101.60 <sup>a</sup>    | 4.31                       |         |
| 6–10                         | 733            | 100.81 <sup>b</sup>    | 3.52                       |         |
| ≤ 5                          | 2,134          | 97.29 <sup>c</sup>     | 0.00                       |         |
| Calf sex                     |                |                        |                            | <0.001  |
| Steers                       | 2,097          | 104.96 <sup>a</sup>    | 8.99                       |         |
| Heifers                      | 1,805          | 95.97 <sup>b</sup>     | 0.00                       |         |
| Color                        |                |                        |                            | <0.001  |
| Black, BWF <sup>3</sup>      | 2,191          | 102.04 <sup>a</sup>    | 2.72                       |         |
| Mixed                        | 634            | 100.34 <sup>b</sup>    | 1.02                       |         |
| Red, RWF <sup>4</sup>        | 718            | 100.16 <sup>b</sup>    | 0.84                       |         |
| White                        | 357            | 99.32 <sup>c</sup>     | 0.00                       |         |
| Vaccinations                 |                |                        |                            | <0.001  |
| 741 <sup>5</sup>             | 1,162          | 101.17 <sup>a</sup>    | 1.58                       |         |
| 4-way viral                  | 893            | 100.63 <sup>a</sup>    | 1.04                       |         |
| No vaccinations <sup>6</sup> | 1,847          | 99.59 <sup>b</sup>     | 0.00                       |         |
| Natural                      |                |                        |                            | 0.24    |
| No                           | 3,742          | 100.79                 | 0.64                       |         |
| Yes                          | 160            | 100.15                 | 0.00                       |         |
| Implants                     |                |                        |                            | 0.74    |
| No                           | 3,783          | 100.57                 | 0.21                       |         |
| Yes                          | 119            | 100.36                 | 0.00                       |         |
| Base weight <sup>7</sup>     | 3,902          |                        | -0.062                     | <0.001  |
| Base weight (quadratic)      | 3,902          |                        | 0.0001                     | <0.001  |

<sup>1</sup>Different superscripts within factor differ at  $P \leq 0.05$ .

<sup>2</sup>Price/hundred pounds.

<sup>3</sup>BWF = black, white face.

<sup>4</sup>RWF = red, white face.

<sup>5</sup>741 = 7-way clostridial plus 4-way viral plus *Pasteurella*.

<sup>6</sup>No vaccination history, but may have 7-way clostridial.

<sup>7</sup>Mean base weight of all lots (625 lb) – base weight of each lot.

Calf sex had an effect ( $P < 0.001$ ) on price. Steer calves sold for \$8.99/cwt more ( $P < 0.001$ ) than heifer calves (\$104.96 vs. \$95.97/cwt, respectively).

Color influenced ( $P < 0.001$ ) calf sale price in the winter months. Black cattle received greater ( $P < 0.001$ ) prices than other colors of cattle. Mixed-color and red cattle were priced similarly ( $P = 0.61$ ) and sold for \$100.25/cwt, which was greater ( $P \leq 0.05$ ) than white cattle (\$99.32/cwt).

An effect ( $P < 0.001$ ) of vaccinations was observed for calves sold in the fall. Calves vaccinated with the 741 vaccination program tended ( $P = 0.07$ ) to be priced greater than calves vaccinated with a four-way viral vaccine. Calves that received vaccinations were priced greater ( $P < 0.001$ ) than calves with no vaccination history (\$100.90 vs. \$99.59/cwt, respectively).

In the winter, prices did not differ ( $P = 0.24$ ) for calves that qualified for a natural program and implant status did not affect ( $P = 0.74$ ) prices producers received in the marketplace. Insufficient lots sold as source and age verified and BQA certified in the fall which prevented determination of the value of those attributes.

These data suggest that the price received for feeder calves in North Dakota, South Dakota and Montana is dependent on multiple factors. Selling vaccinated calves in larger lot sizes seems to be economically advantageous.

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