Beef Cattle and Range Research Report

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Effects of increasing levels of distillers dried grains plus solubles to steers offered moderate-quality forage

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The objective of this study were to determine effects of increasing levels of supplemental distillers dried grain with solubles (DDGS) to steers consuming moderate-quality hay on intake, extent of digestion and ruminal fermentation. Increasing DDGS supplementation resulted in decreased hay organic matter (OM) intake, increased total OM intake and increased OM and crude protein (CP) digestibilities. Using moderate to high levels of DDGS as a forage supplement resulted in no adverse effects on forage digestion and fermentation and resulted in increased nutrient supply in steers fed moderate-quality forage.

Summary

Five ruminally and duodenally cannulated beef steers (981 ± 92 pounds of initial body weight) were used in a 5 by 5 Latin square to evaluate effects of increasing supplemental corn distillers dried grains with solubles (DDGS; 25.4 percent CP, 9.8 percent fat; dry matter (DM) basis) on intake, site of digestion and ruminal fermentation. Diets consisted of a moderate-quality grass hay (10.2 percent CP; DM basis) offered ad libitum, with free access to water and trace mineral salt block, and one of five levels of DDGS. Treatments consisted of DDGS fed at 0, 0.3, 0.6, 0.9 and 1.2 percent BW daily (DM basis). Diets met or exceeded rumen-degradable protein requirements (507 grams per day; microbial yield = 10.5 percent; NRC, 1996). All supplements were fed at 6 a.m. prior to forage. Steers were adapted to diets for 14 days followed by a seven-day collection period. Hay OM intake decreased (linear; $P < 0.001$) while total OM intake increased (linear; $P < 0.001$) with increasing DDGS. Total CP intake and total tract OM digestibility increased (linear; $P < 0.001$) with increasing DDGS. Apparent ruminal, true ruminal and total tract CP digestibility increased linearly ($P \le 0.02$) and total tract CP digestibility increased quadratically ($P = 0.05$) with increasing DDGS. No differences ($P \geq 0.22$) in neutral detergent fiber (NDF) or acid detergent fiber (ADF) digestibility were measured. Average ruminal pH was not different ($P = 0.89$) among treatments. Ammonia concentration increased (linear; $P < 0.001$) with increasing DDGS. Acetate percentage decreased (linear; $P < 0.001$) while propionate and butyrate percentages increased (linear; $P \le 0.05$) with increasing DDGS. Using moderate to high levels of DDGS as a forage supplement resulted in no adverse effects on forage digestion or fermentation and increased nutrient supply to steers fed moderate-quality forage.

Introduction

Increasing forage and pasture demand has resulted in greater summer feed costs for cow-calf producers. Because of these increased costs, partially replacing forage with byproducts in beef cow diets may be economical. Byproducts such as distillers dried grain with solubles (DDGS) are becoming more available and may be a cost-effective source of nutrients. Distillers dried grain with solubles typically contain approximately 30 percent CP, 11 percent fat, and supply 52 percent rumen undegradable protein (NRC, 1996) and are priced competitively with corn grain.

Much research has been conducted evaluating DDGS in beef finishing diets. However, data evaluating supplementing DDGS to cattle consuming forage are limited. Grings et al. (1992) reported no differences in dry-matter intake (DMI) when lactating dairy cows fed alfalfa-based diets were supplemented 0, 10.1, 20.8 or 31.5 percent DDGS of diet DM. Conversely, MacDonald and Klopfen-

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stein (2004) and Morris et al. (2005) reported decreased forage intake with increasing DDGS (up to 65 percent of BW) offered to heifers consuming high (20 percent CP) or low-quality (6 percent CP) forage.

Forage substitution allows for more animal units to graze a pasture. This becomes important when feeding costs are high and forage availability low. Therefore, our objective was to determine effects of increasing supplemental (DDGS) fed to steers consuming moderate-quality hay on intake, rate and site of digestion, and ruminal fermentation.

Materials and Methods

Five ruminally and duodenally cannulated beef steers (981 ± 92 pounds of initial BW) were used in a 5 by 5 Latin square. Steers were weighed at the initiation of the trial and housed in individual pens (9.8-foot by 12.1-foot) during each 14-day adaptation period and stalled in individual metabolism stanchions (3.3-foot by 7.2-foot) during each seven-day collection period. Moderate-quality grass hay, (10.2 percent CP; DM basis) chopped through a 4-inch screen, was offered ad libitum, and steers had free access to water and trace-mineralized salt block. Treatments consisted of DDGS fed at 0, 0.3, 0.6, 0.9 and 1.2 eprcent of BW daily. Analyzed nutrient of hay and DDGS is provided in Table 1. Diets met or exceeded rumen-degradable protein using the NRC model requirements (507 g/d; microbial yield was set at 10.5 percent; NRC, 1996). All supplements were fed at 6 a.m. prior to forage. Treatments were changed every period (21 days) after BW was taken.

Feed refusal samples were collected for determination of DMI. Total fecal output was measured for determination of total tract digestion. Duodenal fluid samples were taken during four days to estimate nutrient flow. Liquid dilution rate was estimated using Co-EDTA as a liquid flow marker. Ruminal fluid samples were collected at several times after supplementation and analyzed for ammonia, volatile fatty acid (VFA) and pH. On day seven of each collection period, prior to morning feeding, ruminal evacuations were conducted to determine ruminal fill and to isolate bacterial samples via differential centrifugation for chemical analyses. All data were analyzed for statistical differences by analysis of variance.

Results and Discussion

Hay OM intake decreased 0.45 pound for every pound of DDGS supplemented and therefore, total OM intake increased (linear; $P < 0.001$; Table 1) with increasing DDGS offered. Morris et al. (2006) reported forage intake decreased 1.66 pounds per pound of DDGS offered to steers grazed on native summer Nebraska Sandhills range. Apparent ruminal and true ruminal OM digestibilities were not altered ($P \geq 0.28$) across treatments; however, total tract OM digestibility increased linearly ($P < 0.001$) with increasing DDGS. No differences ($P \geq 0.29$) in NDF or ADF digestibility were observed (67.6 percent and 64.6 percent of intake, respectively; data not shown). Hannah et al. (1990) fed alfalfa haylage-based diets supplemented with increasing levels of corn gluten feed. They reported increased fiber digestibilities with increasing levels of corn gluten feed, which is primarily branlike DDGS.

By design, total CP intake increased (linear; $P < 0.001$; Table 2) while hay CP intake decreased (linear; $P < 0.001$) with increasing supplementation. Apparent and true ruminal CP digestibilities increased linearly ($P < 0.02$), while total tract CP digestibility increased quadratically ($P = 0.05$) with increasing DDGS. Brokaw et al. (2001) observed greater microbial efficiency for nonsupplemented heifers, compared with corn-supplemented heifers. They attributed this to an increased ruminal fluid passage rate in the nonsupplemental controls. In this study, the fluid dilution rate increased linearly ($P = 0.008$; data not shown) with increasing DDGS; however, no differences were measured for microbial efficiency ($P = 0.25$).

Treatment did not affect ($P \geq 0.31$) ruminal pH or total VFA concentration (Table 3). Molar proportions of acetate decreased linearly ($P < 0.001$) while proportions of propionate and butyrate increased linearly ($P \leq 0.007$) with increasing DDGS. A quadratic ($P = 0.02$) response was observed for ruminal ammonia concentration, with the greatest increase at 0.9 percent of BW as dietary DDGS daily. Similarly, others have reported increased ruminal ammonia concentrations and molar proportions of propionate and butyrate with grain supplementation (Brokaw et al., 2001).

Table 1. Analyzed nutrient content (% of DM) of hay and dried distillers grain with solubles offered to steers.

Item	Hay	DDGS[1]
Ash	11.1	9.6
CP	10.6	25.4
NDF	65.1	34.6
ADF	37.6	10.6
Crude fat	—[2]	9.8
P	—[2]	0.87

[1]Distillers dried grains with solubles.
[2]Not analyzed.

Implications

Supplementing increasing levels of DDGS decreased forage intake while improving OM and CP digestibilities. Distillers dried grains with solubles may be used as a supplement to substitute for moderate-quality forage up to 1.2 percent of BW with no adverse effects on fiber digestion.

Table 2. Effect of distillers dried grains with solubles supplementation on OM and CP intake, flow and digestion in steers fed moderate-quality hay.

	Dietary DDGS, % of BW[1]							Contrast		
Item	0.0%	0.3%	0.6%	0.9%	1.2%	SEM[1]	*P*-value[2]	Linear	Quadratic	Cubic
Organic matter intake, lb/d										
Hay	18.0	17.5	14.2	14.2	12.8	0.7	<0.001	<0.001	0.21	0.18
DDGS[1]	0.00	2.68	5.10	7.83	10.14	0.26	<0.001	<0.001	0.65	0.83
Total	18.0	20.2	19.3	22.0	23.0	0.6	<0.001	<0.001	0.35	0.19
Digestibility, % of intake										
Apparent ruminal	56.5	56.4	57.8	57.2	61.6	1.9	0.28	0.08	0.31	0.98
True ruminal	57.5	57.3	58.8	58.1	62.4	1.9	0.31	0.09	0.32	0.91
Total tract	65.5	68.3	70.9	71.9	73.8	0.9	<0.001	<0.001	0.20	0.91
Crude protein intake, lb/d										
Hay	2.09	1.98	1.61	1.58	1.51	0.08	<0.001	<0.001	0.20	0.39
DDGS[1]	0.00	0.77	1.43	2.23	2.87	0.09	<0.001	<0.001	0.72	0.86
Total	2.09	2.75	3.04	3.80	4.30	0.09	<0.001	<0.001	0.80	0.64
Digestibility, % of intake										
Apparent ruminal	6.9	8.6	20.4	19.6	21.4	4.8	0.10	0.02	0.52	0.64
True ruminal	44.7	42.2	48.4	51.6	58.3	3.6	0.04	0.006	0.24	0.62
Total tract	57.5	63.8	69.5	72.2	75.1	1.3	<0.001	<0.001	0.05	0.86
Microbial efficiency[3]	13.1	12.7	13.3	14.3	15.6	0.9	0.25	0.04	0.30	0.82

[1]n = Five observations per treatment; DDGS = distillers dried grains with solubles.
[2]Probability value for the *F*-test of overall treatment.
[3]Grams of microbial N/kg of OM truly fermented. Truly fermented OM = OM intake - apparent feed OM flow at the duodenum.

Table 3. Effect of distillers dried grains with solubles supplementation on ruminal pH, ammonia and VFA in steers fed moderate-quality hay.

	Dietary DDGS, % of BW[1]							Contrast		
Item	0.0%	0.3%	0.6%	0.9%	1.2%	SEM[2]	*P*-value[3]	Linear	Quadratic	Cubic
pH	6.57	6.51	6.45	6.47	6.48	0.09	0.89	0.45	0.51	0.95
Ammonia, m*M*	1.54	3.15	4.04	4.91	4.45	0.45	<0.001	<0.001	0.02	0.67
VFA										
Total, m*M*	150.4	155.5	150.7	149.7	139.5	8.3	0.73	0.31	0.40	0.98
Acetate, mol/100 mol	77.4	75.8	74.0	72.1	68.8	0.7	<0.001	<0.001	0.26	0.59
Propionate, mol/100 mol	12.6	12.9	13.7	15.2	17.5	0.5	<0.001	<0.001	0.04	0.91
Butyrate, mol/100 mol	7.4	8.2	9.1	9.0	9.1	0.4	0.05	0.007	0.15	0.85
Acetate:propionate	6.16	5.89	5.42	4.79	4.08	0.17	<0.001	<0.001	0.12	0.81

[1]n = Five observations per treatment; DDGS = distillers dried grains with solubles.
[2]n = Five observations per treatment.
[3]Probability value for the *F*-test of overall treatment.

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Comparing three forage types for use in swath grazing: Effects on ruminal fermentation, digestibility and cow performance

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The objectives of these studies were to evaluate cow performance in a swath grazing system on three different forages. A secondary objective was to determine intake, ruminal fermentation and digestibility of the treatment forages. A year by treatment interaction occurred for average daily gain (ADG) and body condition score (BCS) change. No differences were found in 2005, but cows grazing foxtail millet had lower ADG and lower BCS change in 2006. However, foxtail millet had greater intakes and digestibility, compared with other forages.

Summary

The first objective of this study was to evaluate cow performance in a swath grazing system for three different forages: crested wheatgrass (*Agropyron cristatum;* CWG), big bluestem (*Andropogon gerardii;* BBS) and foxtail millet (*Setaria italic;* FM) in a split-plot design. Grazed native range (NR) was the control treatment. Our secondary objective was to determine intake, ruminal fermentation and digestibility of these forages in a 5 by 5 Latin square design. For each of the swath grazing treatments, nonirrigated pasture (30 acres) was divided into three paddocks (10 acres each). Three native range pastures (40 acres) were used as the nonswathed grazed control. A cooked molasses block supplement was included with the BBS due to the low crude protein (CP) content of the forage. Cow performance was similar among treatments in 2005; however swath-grazed BBS and CWG cows increased in BCS, while FM cattle maintained body condition (BC) in 2006. In study 2, FM-fed steers consumed more dry matter (DM) and organic matter (OM), compared with BBS, CWG and NR. Total tract OM, neutral detergent fiber (NDF) and acid detergent fiber (ADF) digestibility was greater in FM, compared with the other forages. Therefore, we conclude that swath grazing is an acceptable alternative to grazing native range for wintering beef cows in central North Dakota.

Introduction

Many comparisons of swath grazing versus baled-forage feeding have been completed with varying results (Turner and Angell, 1987; Munson et al., 1999; Volesky et al., 2002). However, to our knowledge, no direct comparison of a cool-season perennial, a warm-season perennial or a warm-season annual exists in published literature. Volesky et al. (2002) reported calves swath grazing windrows on subirrigated meadows had greater weight gains than bale-fed calves in the first year of a two-year study. However, in the second year, the two groups had similar gains. Schleicher et al. (2001) reported windrow-fed cows on flood-irrigated meadows were 32 pounds heavier and had a greater BCS than bale-fed cows. Turner and Angell (1987) reported similar results in a study that compared hay-fed, standing forage-fed and rake bunch-fed cows on flood-irrigated meadow. In their study, rake bunch-fed cows were 22 pounds heavier than the hay-fed group at the conclusion of the study. Munson et al. (1999) detected no differences in weight gain or BCS when heifers grazed windrowed foxtail millet compared with bale-fed foxtail millet. In contrast, Nayigihugu et al. (2002) reported cows grazing standing corn forage had greater ADG than cows grazing windrowed corn forage. Turner and Angell (1987) reported cows grazing standing flood-irrigated meadow maintained weight but had lower BCS than bale- or windrow-fed cows.

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Materials and Methods

All animal care and handling procedures were approved by the NDSU Institutional Animal Care and Use Committee prior to the initiation of these studies.

Study 1. One-hundred forty-four beef cows (2005) and 102 beef cows (2006) were used in a split-plot design. Cows grazed one of four treatments: 1) grazed native range (NR), 2) swath grazed crested wheatgrass (*Agropyron cristatum,* CWG), 3) swath grazed big bluestem (*Andropogon gerardii,* BBS) or 4) swath grazed foxtail millet (*Setaria italic,* FM). All swath grazing treatment pastures were contiguous and the NR treatment pastures were 1.6 kilometers (km) south on similar soil types. Grazing occurred from Oct. 19 through Dec.15, 2005, and from Oct. 17 through Dec. 1, 2006. Two-day individual body weights and body condition scores were taken at the beginning and end of the trial.

Swath grazing treatment pastures were swathed on Sept. 15. The CWG and BBS first were cut with a sickle mower, then raked into windrows. The FM pasture was swathed using a hay conditioner. Each treatment pasture, except NR, was divided into three 10-acre paddocks using electric fence, providing three (10-acre) replications for each swath grazing treatment. Electric cross fencing was used to limit access in an attempt to increase forage utilization and decrease waste. Nine to 10 days of forage was provided at each fence move. The first area grazed was immediately adjacent to a water source, and cross fences were moved to allow access to water and previously grazed areas. Native range treatment groups were allowed to graze the entire pasture to simulate a typical fall-winter management scenario. The supplement for BBS treatment consisted of a 40 percent CP cooked molasses block (Ridley Inc., Mankato, Minn.). All treatments were provided with trace mineral salt blocks (Cutler-Magner Co., Duluth, Minn.) on an ad libitum basis.

Stocking rates were determined at swathing and were based on estimated forage production. Estimated forage production was multiplied by an 80 percent harvesting efficiency and an 80 percent swath utilization. Subsamples of CWG, BBS and FM swaths were collected for analysis. Swath samples were taken as random grab samples on each day the cross fences were moved. Forage samples from NR were collected by clipping 0.25m^2 plots on each day of a cross fence move.

Study 2. Five ruminally and duodenally cannulated beef steers (1,166 ± 71 pounds) were used in a 5 by 5 Latin square design to determine intake and digestion of forages from a companion swath grazing study. Treatments were 1) big bluestem (BBS), 2) big bluestem with protein supplement (BBS/S), 3) crested wheatgrass (CWG), 4) foxtail millet (FM) and 5) native range (NR). Steers were offered ad libitum access to the treatment forages, and for BBS/S, a protein supplement (40 percent CP cooked molasses block; Hubbard Feeds Inc., Mankato, Minn.) was offered (0.16 percent BW). All forages were harvested at the Central Grasslands Research Extension Center near Streeter, N.D. The forages were collected from the swath grazing trial pastures; for native range forage, a site with typical plant species was selected and harvested at the same time the swath-grazed forages were baled. Total fecal collections and orts were collected for seven days to obtain intake and total tract digestibility data.

Results and Discussion

Study 1. Crude protein content of FM and NR both decreased quadratically throughout the grazing season ($P = 0.04$ and $P = 0.03$, respectively; Table 1). However, BBS and CWG CP content did not change during the grazing season.

A year by treatment interaction ($P < 0.001$) was observed for ADG. Cattle grazing BBS gained less weight ($P \le 0.07$; Table 2) than NR grazing cattle in 2006. However, CWG and NR were similar ($P = 0.32$). Cattle grazing FM lost weight ($P < 0.001$). Cattle grazing BBS and CWG had no change in BW (ADG = 0 pounds/day; $P = 0.46$) in 2005, but gained ($P <$

Table 1. Crude protein content (%, DM basis) of swathed big bluestem, crested wheatgrass and foxtail millet compared with standing native range in Streeter, N.D. 2006.

Days of grazing	Treatment[1] BBS	CWG	FM	NR	SE	*P*-value[2] TRT
1	8.02[a]	13.69[b]	12.64[b]	11.32[b]	1.24	0.02
8	7.01[a]	14.60[b]	9.32[c]	7.97[ac]	0.81	<0.001
16	8.86[a]	15.45[b]	9.23[a]	8.54[a]	1.29	0.005
24	7.71[a]	14.28[b]	9.24[c]	8.16[ac]	0.57	<0.001
31	7.91[a]	12.97[b]	7.92[a]	7.68[a]	0.53	<0.001
37	7.16[a]	14.16[b]	8.53[a]	8.32[a]	0.94	0.001
SE	0.65	0.78	0.70	0.66		
P-value (date)	0.45	0.40	0.01	0.03		
linear	0.63	0.59	0.002	0.01		
quadratic	0.40	0.34	0.04	0.03		
cubic	0.52	0.11	0.28	0.22		

[a,b,c]Means within row having differing superscripts differ $P < 0.10$.
[1]Treatment abbreviations BBS = big bluestem, CWG = crested wheatgrass, FM = foxtail millet, NR = native range.
[2]P < 0.10 are considered significant.

0.01) weight (0.7 and 0.9 pound/day) in 2006. Average daily gain of cows grazing swathed FM decreased from (0.2 pound/day) in 2005 to (-1.3 pounds/day) in 2006. Cattle grazing NR gained weight in 2005 (0.2 pound/day), but gained more weight in 2006 (1.1 pounds/day). A significant year by treatment interaction occurred for change in BCS (P = 0.04). In 2005, no differences were observed in BCS change (P = 0.12). However, in 2006, cows grazing FM lost BCS while the other treatments increased in BC, but did not differ from one another.

Study 2. Dry-matter intake was less for cattle fed BBS ($P \leq 0.06$; Table 3), compared with BBS/S, FM and NR. Total tract OM digestibility was greater ($P \leq 0.006$) for FM than all other forages. Total tract CP digestibility was lowest ($P \leq 0.09$) for BBS; however, BBS was similar (P = 0.19) to NR. Total tract NDF and ADF digestibility were similar for BBS, BBS/S, CWG and NR. However, total tract NDF and ADF digestibility of FM was greater than the other forages tested.

Table 2. Average daily gain and change in body condition score of cows under swath grazing and native range grazing management in Streeter, N.D., in 2005 and 2006.

	Treatment[1]					*P*-value[2]	
Item	BBS	CWG	FM	NR	SE	Trt	Yr*Trt
2005 ADG, lbs/d	0.0	0.0	0.2	0.2	0.20	0.46	<0.001
2006 ADG, lbs/d	0.7[a]	0.9[ab]	-1.3[c]	1.1[b]	0.24	<0.001	
SE	1.3	0.2	0.1	0.2			
P-value (Year)	0.12	0.12	0.02	0.10			
2005 ΔBCS	0.2	0.0	0.0	-0.1	0.12	0.12	0.04
2006 ΔBCS	0.5[a]	0.7[a]	0.1[b]	0.7[a]	0.21	0.05	
SE	0.14	0.13	0.05	0.12			
P-value (Year)	0.27	0.11	0.53	0.01			

[a,b,c]Means within row having differing superscripts differ P < 0.10.
[1]Treatment abbreviations BBS = big bluestem, CWG = crested wheatgrass, FM = foxtail millet, NR = native range.
[2]P < 0.10 are considered significant.

Table 3. Intake and total tract digestion of swathed big bluestem, crested wheatgrass and foxtail millet compared with native range forage.

	Treatment[1]						*P*-value[2]
Item[3]	BBS	BBS/S	CWG	FM	NR	SE	Trt
DMI, lb/d	11.2[a]	16.7[b]	13.2[ac]	20.2[d]	15.0[b]	1.3	<0.001
OMI, lb/d	10.1[a]	15.2[b]	12.5[ab]	18.7[c]	13.6[b]	1.1	<0.001
CPI, lb/d	0.5[a]	1.1[b]	0.9[bc]	1.7[d]	0.8[c]	0.1	<0.001
ADFI, lb/d	4.6[a]	6.6[ab]	6.6[ab]	9.5[b]	6.4[ab]	1.1	0.03
NDFI, lb/d	8.1[a]	11.4[b]	9.7[ab]	14.1[c]	10.6[ab]	0.7	<0.001
TTOMD, %	48.6[a]	51.4[a]	48.1[a]	66.5[b]	52.4[a]	4.2	<0.001
TTCPD, %	26.5[a]	43.9[b]	43.1[b]	58.2[c]	40.5[ab]	6.0	0.003
TTADFD, %	45.5[a]	46.2[a]	43.7[a]	66.9[b]	47.9[a]	5.6	0.004
TTNDFD, %	48.2[a]	49.2[a]	45.7[a]	66.8[b]	50.6[a]	5.1	0.001

[1]Treatment abbreviations BBS = big bluestem, BBS/S = big bluestem with supplement, CWG = crested wheatgrass, FM = foxtail millet, NR = native range.
[2]Significance P-value ≤ 0.10.
[3]Abbreviations DMI = dry matter intake, OMI = organic matter intake, ADFI = acid detergent fiber intake, NDFI = neutral detergent fiber intake, TTOMD = total tract organic matter digestibility, TTCPD = total tract crude protein digestibility, TTADFD = total tract acid detergent fiber digestibility, TTNDFD = total tract neutral detergent fiber digestibility.
[a,b,c]Means within row having differing superscripts differ P < 0.10.

Implications

Swath grazing is a viable option for producers to winter beef cows in south-central North Dakota. Attention should be paid to forage quality at the initiation of grazing. Research shows advantages favoring annual forages in both intake and digestibility. If forage quality is too low to support maintenance of cows, supplementation may be required and will directly affect the overall economic feasibility of this type of management.

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Johne's disease in North Dakota (1995-2005): Trends and selected risk factors

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The incidence of Johne's disease is reportedly on the increase in many countries worldwide, including the United States, with considerable economic losses primarily in dairy herds. The objective of this study was to evaluate trends and risk factors of Mycobacterium avium subspecies paratuberculosis (MAP) shedding in cattle in North Dakota using North Dakota State University Veterinary Diagnostic Laboratory records (1995 to 2005). Of the 53 counties in the state, 42 (79 percent) reported MAP infection (range 1 - 86, median 6) in both beef (n = 204) and dairy cattle (n = 175). This indicates that MAP infection was widespread in the state. The state had an increase in MAP cases reported from 1995 to 2005 with higher shedding occurring during the winter and spring months than summer and fall. Herd size, season, gender, age and breed were significantly associated with the shedding status of the animal. Large herds, females, beef animals and animals greater than 4 years of age were more likely to be categorized as high MAP shedders. This information is useful to the state in determining future policy, research and control of Johne's disease in livestock.

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Introduction

Mycobacterium avium subspecies *paratuberculosis* (MAP) is the cause of Paratuberculosis, or Johne's disease, a chronic, untreatable disease affecting domestic and wild ruminants (Olsen et al., 2002). In recent years, the incidence of Johne's disease is reportedly increasing in many countries worldwide, including the U.S. Considerable economic losses primarily occur in the dairy herds (Ott et al., 1999). Various studies have documented major economic losses incurred by the dairy and beef cattle industry due to decreased production, weight loss, lower slaughter value and premature culling of infected cattle (Ott et al., 1999). Major obstacles to control of Johne's disease have been identified as difficulty in identifying infected animals that are not showing clinical signs (Olsen et al., 2002) and a wide host range that includes domestic and wild animals (Olsen et al., 2002). Studies have shown that only one in 20 of the infected animals will show clinical signs of Johne's disease, thus making early detection and complete removal from the herd difficult (Tiwari et al., 2006). Furthermore, MAP has become a public health concern because DNA from this agent has been found in 69 percent of patients with Crohn's disease (a debilitating chronic intestinal infection), suggesting it may be a factor in the causation of this disease (Sechi et al., 2004). While this association remains unproven and contentious, public perceptions of a causal link represent one of the most important economic risks to the milk and meat industries.

In the U.S., a study reported up to 35 percent of the national herd to be infected with MAP, with an estimated loss of $1.5 billion to the agriculture industry every year (Ott et al., 1999). Due to its increasing economic importance and public health concerns, many states within the U.S. have instituted Johne's disease certification programs for eradication. The North Dakota Voluntary Johne's Disease Control Program (CVJDCP) was instituted in 2001 to screen state herds for MAP. CVJDCP participating farmers routinely submit fecal samples together with the disease history form filled by the area veterinarian to state diagnostic laboratories (SDL) for MAP diagnosis (Bulaga and Collins, 1999). Review of compiled information from SDL is therefore important in monitoring effectiveness and making necessary adjustments in the Voluntary Johne's Disease Control Program. The objective of this study was to evaluate trends and risk factors for MAP shedding in cattle in North Dakota, using data collected between1995 and 2005 from North Dakota State University Veterinary Diagnostic Laboratory (NDSU-VDL) in Fargo, N.D.

Procedures

Veterinary medical records of MAP infections in cattle, diagnosed by fecal culture at the NDSU-VDL from 1995 to 2005, were examined. Additionally, data on clinical history, age, sex, breed, shedder status, herd size, season and county of origin of each case were extracted. The distribution of MAP-positive cattle and the producers enrolled in the CVJDCP were mapped by county. Animals were classified as high or low shedders of MAP based on whether MAP colonies following fecal culture took less or more than two weeks, respectively, to appear. The seasons were classified as winter (December to February), spring (March to May), summer (June to August) and fall (September to November). Age and herd size were dichotomized, using their medians as the cutoff (above as high and below as low). Associations between MAP shedding and the following characteristics of cattle (age, sex, county of origin, breed, herd size, number in herd affected and season) were assessed.

Results

In total, 562 fecal samples from cattle in 42 of the 53 counties in North Dakota submitted to NDSU-VDL between 1995 and 2005 were diagnosed as positive for MAP infection. Case numbers varied from one to 86 (median = six) in the counties that submitted samples (Figure 1). Of the completed entries, 47.1 percent of the cases were dairy (n = 197), while 52.9 percent (n = 221) were beef breeds. All the dairy breeds were Holstein 100 percent (n = 197), while the beef were Angus, 49.3 percent (n = 109); Gelbveigh, 16.3 percent (n = 36); crossbreeds, 9 percent (n = 20); Shorthorn, 5.4 percent (n = 12); Limousin, 4.1 percent (n = nine); Simmental, 4.1 percent (n = nine); Brahman,1.8 percent (n = four); Charolais, 1.8 percent (n = four); Hereford, 1.8 percent (n = four); Black Maine, Corrient, Longhorn and Tarentaise cross, each 0.9 percent (n = two); and others, 3 percent (n = six). Breeds classified as "others" included Bucking bull (one), Normande (one), Saler (one) and Suffolk (one). Figure 1 shows the distribution of MAP cases per county in North Dakota from 1999 to 2005 (n = 467; county information was missing (n = 95) for 1995-1998). Figure 2 shows the distribution by county of producers participating in the CVJDCP as of March 22, 2007 (n = 173). Variations in the case reports by breed and year of reporting, 1995 to 2005, are given

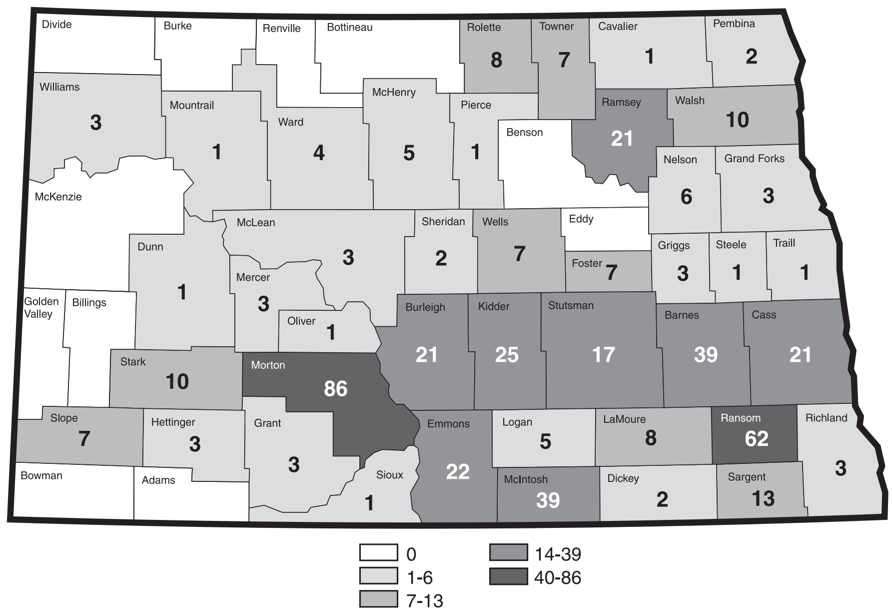

Figure 1. Spatial distribution by county of fecal culture-positive cases of ***Mycobacterium avium*** **subspecies** ***paratuberculosis*** **infection in cattle in North Dakota, 1999 – 2005 (n = 467).**

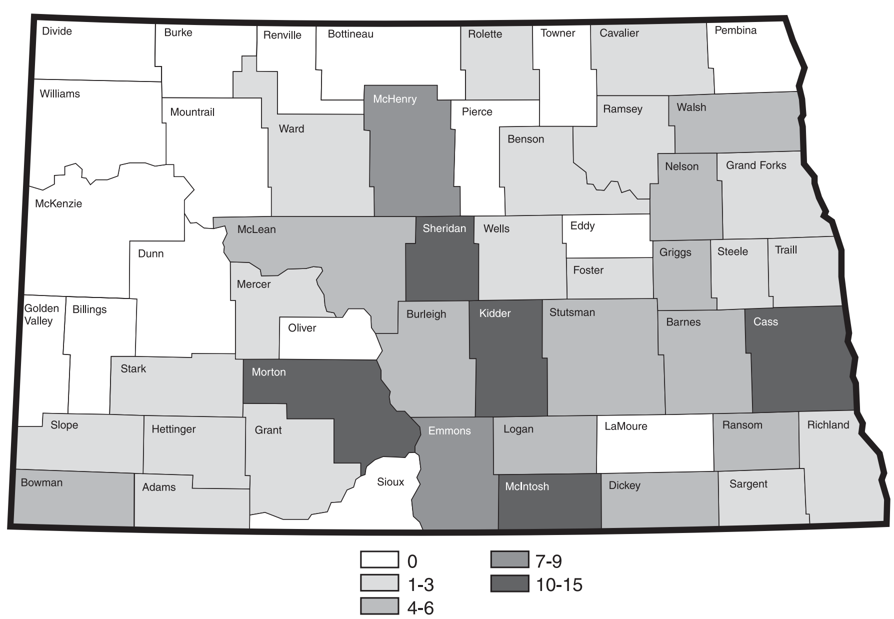

Figure 2. Distribution by county of producers participating in the North Dakota Voluntary Johne's Disease Control Program as of March 22, 2007 (n = 173).

in Figure 3. The proportion of positive cases between the beef (52.9 percent, n = 221/418) and dairy breeds (47.1 percent, n = 197/418) was comparable (Figure 3), although the breeds status for 144 other animals was not reported. Eighty-eight percent (n = 494/562) of the MAP cases were reported from 2001 to 2005 following introduction of the CVJDCP in 2001. On the other hand, 58 percent of the cases (n= 327/562) were reported between 2004 and 2005 (Figure 3), showing a very marked increase in the last two years. Figure 4 shows the breed cumulative incidence of MAP per 10^6 cattle initially at risk in North Dakota by year of reporting. Figure 5 shows the variation in the monthly trend in the mean number of culture-positive MAP cases reported during the period 2000 to 2005 (n = 508, detailed information missing (n = 54) for 1995-1999). Trends show the highest mean number of positive MAP cases during February and March (Figure 5), corresponding to late winter and early spring. High fluctuations were observed during May-July and November-December. The proportion of cattle infected with MAP was higher in older animals (71 percent) than younger ones (29 percent), and in female cattle (93 percent), compared with males (7 percent). Seasonality in the shedding pattern of MAP also was detected, with higher MAP cases diagnosed in colder months (38 percent and 25 percent in winter and spring, respectively) than warmer months (19 percent and 18 percent in summer and fall, respectively). MAP shedding status (high vs. low) among infected cattle was found to be significantly ($P < 0.05$) associated with herd size, gender, breed and season (Table 1), while age category was not ($P > 0.05$). Most data on "number of sick cattle in the herd" were missing, so meaningful analysis on this factor could not be run.

Discussion

This study indicated a widespread distribution (42 out of 53 counties) of MAP infection in North Dakota (Figure 1). Also, the study found a correlation between distribution of cases by county (Figure 1) and distribution of producers participating in the CVJDCP (Figure 2), with participating counties having more MAP cases reported than counties without participants. Also evident was that the year 2000, which was prior to the introduction

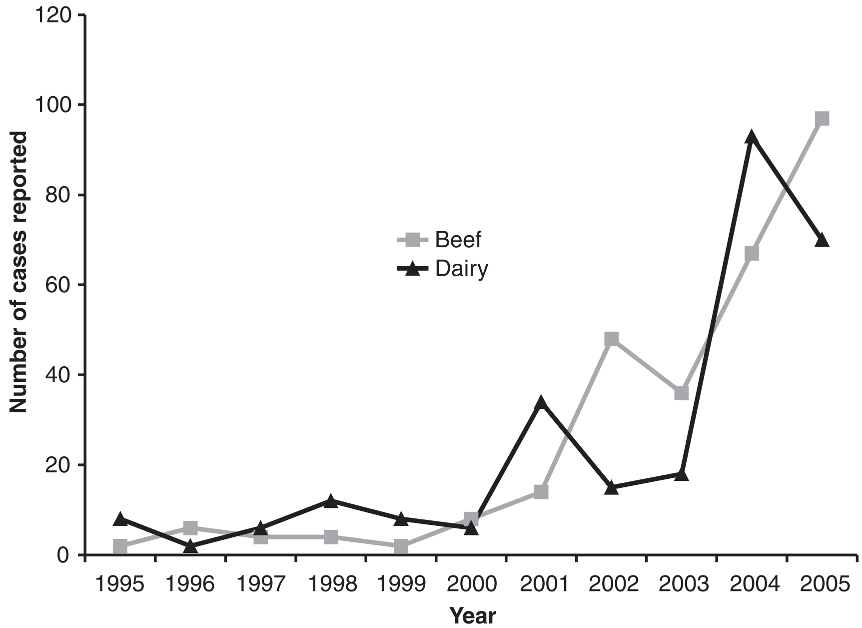

Figure 3. Distribution by breed and year of reporting of fecal culture-positive cases of *Mycobacterium avium* subspecies *paratuberculosis* infection in cattle in North Dakota, 1995 – 2005 (n = 562).

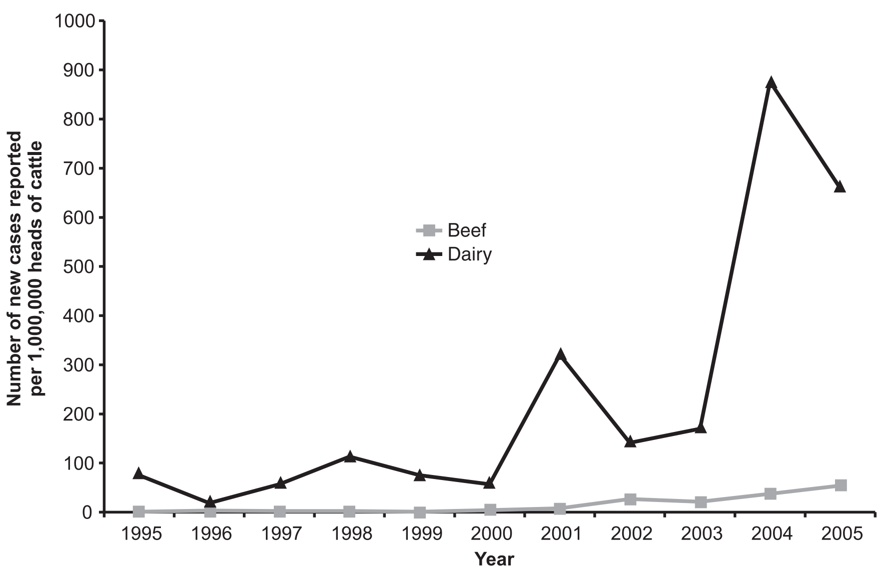

Figure 4: Cumulative incidence by breed and year of reporting of fecal culture-positive cases of *Mycobacterium avium* subspecies *paratuberculosis* infection per 10^6 cattle initially at risk in North Dakota (2000-2005).

of the CVJDCP, reported the lowest percent of positive submissions, with the majority of cases (88 percent, n = 494/562) reported between 2001 and 2005 following introduction of the CVJDCP in 2001. This observation highlights the importance of CVJDCP participation as a way of increasing Johne's disease testing in the state. Moreover, the appearance of an upward trend in the case reports is strongly suggestive that not all infected animals are being detected and removed before they start shedding. Early identification of MAP clinical shedders remains difficult (Whitlock and Buergelt, 1996) partly due to low sensitivity of the tests used and the presence of subclinically infected cows in the herds, which may substantially increase risk of infection.

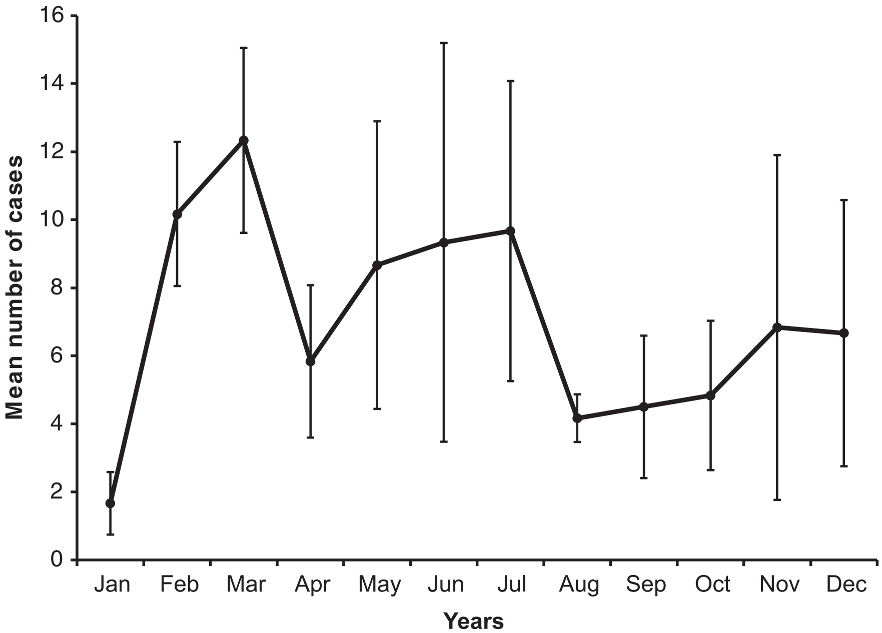

Figure 5. Mean number of fecal culture-positive cases of *Mycobacterium avium* subspecies *paratuberculosis* infection in cattle in North Dakota by month, 2000 to 2005 (n = 508).

Table 1. Associations between shedding status of *Mycobacterium avium* subspecies *paratuberculosis*-infected cattle and a few selected factors, 1995-2005

Factor	Category	No. of Units tested	Percent high MAP shedder (%)	*P* value
Herd size (numbers)	Large (≥144)	46	52.2	0.006
	Small (<144)	42	23.8	
Gender	Female	317	23.3	0.043
	Male	24	41.7	
Within season variability	Winter	163	17.2	0.009
	Spring	133	33.8	
	Summer	87	24.1	
	Fall	80	21.3	
Between season comparison	Winter vs Fall			0.157
	Spring vs Fall			0.003
	Summer vs Fall			0.436
Breed	Beef	195	29.7	0.003
	Dairy	169	16.6	
Age (Years)	≤1	8	62.5	0.111
	2-3	61	27.9	
	≥4	156	28.2	

The trend from 1995 to 2005 showed a rise in case reports (Figure 3) and cumulative incidence (Figure 4) of MAP infection. What was noteworthy is the peaking of case reports and cumulative incidence in dairy breeds every three years (1995, 1998, 2001 and 2004), suggesting existence of a three-year cyclical trend in North Dakota. This observation was more pronounced in dairy than beef cattle. It could suggest the mean time required for a newly infected animal to transition from silent through subclinical to clinical infection, the time when MAP testing is likely to be performed. The overall rising trend in MAP case reports in part is in agreement with other studies that have reported that Johne's disease occurs with increasing frequency and tendency to endemicity (Manning and Collins, 2001).

Because our results do not show whether new cases were a result of more farmers responding to the program or an actual increase in number of cases, an annual review of the control strategies in North Dakota is highly recommended. A quick scan of the distribution of case reports between beef (52 percent) and dairy breeds (48 percent) in North Dakota (Figure 3 and 5) indicates that the infection in the two breed groups are comparable; however, on considering the population distribution of the two breed groups in the state, MAP cumulative incidence was higher in dairy than beef breeds, while individual animals ranked as higher MAP shedders were more evident in beef than dairy cattle (Table 1). Studies have linked this to poor hygiene conditions of beef farms (Rousel et al., 2005). Sanitary practices to decrease the risk of new infection with MAP may be difficult to implement around calves, beef or large herds, while these may be mandatory in dairy operations to control mastitis (Goodger et al., 1996).

A higher proportion of older animals (71 percent) was infected with MAP than younger ones (29 percent), possibly due to the prolonged preclinical phase of this lifelong infection. Age might explain higher MAP incidence in dairy than beef cattle since dairy cattle generally live longer. Larger herds were more likely to have heavy MAP shedders than smaller ones, suggesting management as a risk factor. This agrees with a 1996 Dairy National Animal Health Monitoring System (NAHMS) study (USDA:APHIS, 1997), which reported that larger herds (> 300 cows) were more likely to be infected than smaller herds (< 50 cows). In the present study, a possible explanation for the presence of high shedders in large herd sizes could be attributed to the increased closer physical contact between individual animals leading to more effective contact between infected and noninfected animals in large herds, as opposed to smaller herds. Additionally, a higher proportion of female (93 percent) than male (7 percent) cattle were infected with MAP ($P = 0.043$). This could be attributed to the chronic nature of the disease and longer period female animals (both dairy and breed) are kept for breeding. Though the proportion of high MAP shedders was greater in animals ≥ 4 years of age, this was not significant ($P > 0.05$). This is contrary to earlier studies (Whitlock and Buergelt, 1996) in which high shedding was associated with increasing age.

A seasonality in the shedding pattern of MAP also was detected, with a higher shedding in colder months (winter and spring), as opposed to warmer months (summer and fall), despite most samples being submitted in the fall. This is in agreement with other studies that found a greater MAP incidence during the winter months (Roussel et al., 2005). A likely explanation for the difference in prevalence and shedding rate between spring and summer could be the effects of overwintering on body condition and/or the stress associated with the onset of the breeding season in the spring. Incidentally, spring in North Dakota also coincides with the breeding period. It is also the time when many mammals are in their worst body condition after surviving the harsher conditions of winter.

Summary

In summary, this study demonstrated the widespread occurrence of MAP and documented some risk factors for MAP shedding in cattle in North Dakota (1995 to 2005). It also provided information on the progress of the control programs for bovine Johne's disease in North Dakota, helping identify some critical areas for further research and intervention. This study further justifies examination of laboratory data to strengthen and add value to state and national disease monitoring and surveillance efforts, and ensure optimal use of the information contained in the system.

Acknowldgements

The authors thank the North Dakota State University Veterinary Diagnostic Laboratory and North Dakota State Veterinarian's Office for providing the data.

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Salmonella occurrence in North Dakota forage-fed beef cattle: Prevalence, characterization and comparison with reports from the Veterinary Diagnostic Laboratory

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Salmonella is one of the most widespread foodborne pathogens worldwide. Food animals, including cattle, are the most important source of human Salmonella infections. The objectives of this study were: 1) To determine the prevalence, serotypes and antimicrobial resistance patterns of Salmonella isolates recovered from forage-fed cattle in North Dakota and 2) To evaluate Salmonella occurrence from submissions to the North Dakota State University Veterinary Diagnostic Laboratory (NDSU-VDL).

Summary

The prevalence of *Salmonella* in forage-fed cattle was 7.1 percent (15 of 212), distributed throughout four counties. Thirteen (87 percent) of the 15 *Salmonella* isolates recovered were *Salmonella* Typhimurium (Copenhagen) and the rest (two of 15, 13 percent) were *Salmonella* Worthington. All 15 *Salmonella* isolates from healthy cattle were resistant to more than 10 antimicrobials. In 2004, 37 bovine salmonellosis cases were diagnosed at the NDSU-VDL, mostly during winter and spring. Of the 25 isolates from the NDSU-VDL tested for antimicrobial resistance (AMR), 100 percent exhibited multidrug resistance (MDR). Overall, the clinical isolates showed similar antimicrobial resistance patterns as did the serovars recovered from healthy cattle. These data show that MDR is widespread among the *Salmonella* recovered from apparently healthy forage-fed cattle and from clinical salmonellosis cases. This justifies continued surveillance of this organism from multiple sources.

Introduction

Foodborne diseases cause an estimated 76 million illnesses, 325,000 hospitalizations and 5,000 deaths in the United States each year (Mead et al., 1999). Among the infectious foodborne pathogens, *Salmonella* is one of the most widespread worldwide (Mead et al., 1999). This agent is associated with enteric infections in both humans and animals. Although human salmonellosis has been associated with exposure to other vehicles of transmission (e.g. pets, reptiles and contaminated water), an estimated 95 percent of the cases involve foodborne transmission, with mostly foods of animal origin, such as beef (Mead et al., 1999).

The prevalence of *Salmonella* on the external surfaces (hides) of cattle upon entry in commercial packing facilities is an indication of contamination that potentially could lead to carcass contamination during the de-hiding process. Moreover, a correlation between fecal shedding of *Salmonella* and the prevalence of *Salmonella* on cattle hides/external surfaces has been reported (McEvoy et al., 2003). Adult cattle are a reservoir of this agent and usually harbor the organism in the digestive tract. These subclinical adult carriers may shed the organisms in feces without suffering any overt disease; however, overt disease occasionally occurs in calves.

Much research has been done on *Salmonella* occurrence in dairy cattle, but very few studies have focused on beef cattle. Also, the literature contains reports of *Salmonella* occurrence in cattle approaching slaughter (Beach et al., 2002). These reports underscore the need for control of these foodborne pathogens pre-slaughter. Reducing the shedding of these organisms by cattle pre-slaughter is a positive step in addressing this problem at the early stages

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of the food chain.No recommended measures are available for cattle producers to reduce subclinical shedding of these potential foodborne pathogens by their cattle. Using pre-Hazard Analysis and Critical Control Points (HACCP) baseline data, *Salmonella* performance standards in the US PR-HACCP Final Rule were established at 1 percent, 2.7 percent and 7.5 percent for steers/heifers, cows/bulls and ground beef, respectively (anonymous, 1996). However, with the full implementation of HACCP by meat processors, incentives likely will be provided in the future to producers who can supply low-risk animals. This could lessen the opportunity for contamination of the final product with *Salmonella*. In addition, at least a portion of the liability for contaminated meat products possibly will be shared by the original producer. If these changes occur, then producers will require prevention and control programs that will reduce pathogen loads in their cattle while maintaining animal health.

Recently, the emergence of multi-drug-resistant bacteria has become an important worldwide concern for both human and veterinary medicine because of the potential for treatment failures. Antimicrobial resistance among bacterial isolates from animals also has become a concern because of the potential for these organisms to be foodborne pathogens or to be donors of resistance genes to human pathogens (Lathers, 2001). The Centers for Disease Control and Prevention (CDC) reported that to address the problem of AMR, surveillance has to be done both in humans and food animals. The objectives of this study were: 1) To determine the prevalence, serotypes and antimicrobial resistance patterns of *Salmonella* isolates recovered from forage-fed cattle in North Dakota and 2) To evaluate *Salmonella* occurrence from submissions to the NDSU-VDL.

Procedure

A total of 212 cattle (97 calves and 115 cows) originating from seven cow-calf farms in the North Dakota counties of Billings, Dunn, Mercer and Stark participated in the study. The animals were part of a larger group of cow-calf herds that were enrolled in the North Dakota Animal Identification project in August 2004. The seven cow-calf farms are the ones whose owners were willing to participate in the study. A random sample of at least 30 cattle (15 calves and 15 adult cows) was selected from each of the seven herds that participated in the study except where fewer than 30 animals in each category were available; in that case, all of them were sampled. One herd had only calves and two herds had only adult cows, so 30 animals of one category were sampled from each of these herds. Approximately 20 grams of feces were obtained from the rectum of individual cattle and shipped by FedEx overnight to the Department of Veterinary and Microbiological Sciences at North Dakota State University. The fecal samples were processed within 24 hours of their arrival at the laboratory.

The fecal samples were cultured in the laboratory, using culture methods optimized for the detection of *Salmonella* (McEvoy et al., 2003) in fecal specimens. Presumptive *Salmonella* isolates were sent to the National Veterinary Services Laboratories in Ames, Iowa, for serotyping. Antimicrobial susceptibility of *Salmonella* isolates was determined using a custom designed panel according to the manufacturer's instructions (Sensititre, Trek Diagnostics, Westlake, Ohio). The antimicrobials tested included ampicillin, apramycin, ceftiofur, chlortetracycline, clindamycin, enrofloxacin, erythromycin, florfenicol , gentamicin, neomycin, oxytetracycline, penicillin, spectinomycin, sulphachloropyridazine, sulphadimethoxime, sulphathiazole, tiamulin, tilmicosin, trimethoprim/sulphamethoxazole and tylosin. Geographical information systems (GIS) were used to show the distribution of *Salmonella* cases in North Dakota by county. The proportions of major serotypes recovered, plus their AMR profiles, were summarized in a table. Data on *Salmonella* recovered from submissions to the NDSU-VDL for the years 2000-2005 were retrieved from their records. Epidemiological information was extracted from the submission forms and consisted of age, gender, county and type of sample submitted (feces, tissue, dead animal), and whether the animal was dead or alive. Additionally, a random sample of 25 *Salmonella* isolates from the NDSU-VDL was tested for AMR as described above.

Results

***Salmonella* prevalence:** A total of 212 cattle (115 adult cattle, 97 calves) was sampled. Overall, 15 (7 percent) of the 212 cattle sampled tested positive for *Salmonella*. The prevalence of *Salmonella* among adult cattle and calves was nine of 115 (7.8 percent) and six of 97 (6.2 percent), respectively. The 15 cattle that tested positive for *Salmonella* were distributed in three of the four counties, with the majority originating from Billings County and no animals from Mercer County as follows: Stark (seven of 92, 7.6 percent), Billings (five of 30, 6.6 percent), Dunn (three of 60, 5 percent) and Mercer (0 of 30, 0 percent). The spatial distribution by county of the *Salmonella*-positive cattle is shown in Figure 1.

***Salmonella* serotypes isolated:** Thirteen (87 percent) of the 15 *Salmonella* isolates recovered were *Salmonella* Typhimurium (Copenhagen) and the rest (two of 15, 13 percent) were *Salmonella* Worthington.

Antimicrobial resistance patterns of *Salmonella* isolates from healthy cattle and the NDSU-VDL: Antimicrobial resistance patterns of isolates of *Salmonella* from healthy cattle (n=15) and clinical isolates from sick cattle (NDSU-VDL) (n=25) are presented in Table 1. All 15 *Salmonella* isolates from healthy cattle were susceptible to apramycin, ceftiofur, entrofloxacin, gentamicin and neomycin. All samples were resistant to chlortetracycline, clindamycin, erythromycin, florfenicol, oxytetracycline, penicillin, sulphachlorophridazine, sulphadimethoxime, sulphathiazole, tiamulin and tilmicosin. Two isolates (both *Salmonella* Worthington) were susceptible to ampicillin, whereas the other 13 samples (all *Salmonella* Typhimurium (Copenhagen) were resistant to ampicillin. Also, for the same two samples, the test could not determine their susceptibility or lack thereof to spectinomycin, whereas the rest of the samples (13) all were resistant to spectinomycin (Table 1). Most *Salmonella* isolates from sick animals were resistant to the antimicrobial agents used in the treatment of animal diseases (Table 1).

Salmonella occurrence from submissions to the NDSU-VDL: In 2004, 37 salmonellosis cases were diagnosed at the NDSU-VDL, of which six (16.2 percent) were adult animals, 26 (70.2 percent) were less than 9 months of age and five (13.5 percent) were of unknown ages. Twelve (32.5 percent) were bovine, four (10.8 percent) were other species (bison, equine, ovine, porcine, mink, wildlife) and 11 (29.7 percent) unknown species. Seven (18.9 percent) were male and 13 (35.1 percent) were female, with 17 (45.9 percent) of unknown gender. Of samples submitted, 26 (70.3 percent) were tissue samples and 11 (29.7 percent) were fecal samples. Twenty-six (70.3 percent) cases arrived dead and 11 (29.7 percent) had samples from a live animal. Of those isolates, nine (24.3 percent) were submitted during the winter, 14 (37.8 percent) in the spring,11 (29.7 percent) during the summer and 3 (8.1 percent) in the fall. The seasons were defined as winter (Dec. 21- March 21), spring (March 22- June 21), summer (June 22 - Sept. 23) and fall (Sept. 24- Dec. 20).

In 2005, 22 salmonellosis cases were diagnosed at the NDSU-VDL. Six (27.3 percent) of those were diagnosed during the winter, five (22.7 percent) in the spring, nine (40.9 percent) during the summer and two (9.1 percent) in the fall. Species were bovine, 13 (59.1 percent), and others (bison, equine, porcine, ovine, mink, wild life), which totaled nine (40.9 percent) cases. For the period 2000-2005, a total of 303 salmonellosis cases were diagnosed at the NDSU-VDL; of those, 78 (25.7 percent) were during the winter, 102 (33.7 percent) in the spring, 79 (26.1 percent) during the summer and 44 (14.5 percent) in the fall. Species consisted of bovine, 167 (55.1 percent), and others (136, 44.9 percent) which consisted of bison, equine, porcine, ovine, mink and wild life.

Salmonella serotypes isolated from NDSU-VDL submissions: In 2004, the 37 *Salmonella* isolates recovered

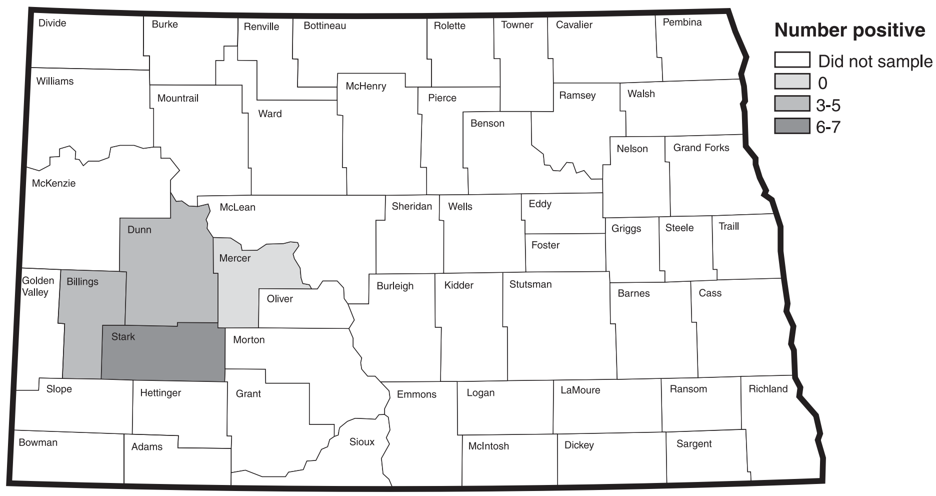

Figure 1. Geographic distribution (by county) of cattle that tested positive for *Salmonella:* North Dakota-2004 (N=15).

Table 1. Antimicrobial resistance of *Salmonella* isolates recovered from grass-fed cattle in North Dakota, as well as clinical salmonellosis cases from the NDSU-VDL.

	Number resistant (%)	
Antimicrobial	Healthy cattle (n=15) number (%)	NDSU-VDL (n=25) number (%)
Ampicillin	13(87)	13(52)
Chlorotetracycline	15(100)	13(52%)
Clindamycin	15(100)	n/a
Erythromycin	15(100)	n/a
Florfenicol	15(100)	13(28)
Neomycin	n/a	9(36)
Oxytetracycline	15(100)	14(56)
Penicillin	15(100%)	n/a
Spectinomycin	13(87)	25(100)
Sulphachloropyridazine	15(100)	24(96)
Sulphadimethoxine	15(100)	24(96)
Sulphathiazole	15(100)	13(52
Tiamulin	15(100)	25(100)
Tilmicosin	15(100)	25(100)

n/a = Not applicable (was sensitive or no results available).

from the NDSU- VLD submissions originated from North Dakota, South Dakota and Minnesota. The major serotypes were S. Typhimurium (51.4 percent), Dublin (8.1 percent), Derby (8.1 percent) and unknown strains (10.8 percent); the remaining 21.6 percent was made up by Muenster, Mbandaka, Kentucky, Heidlebert, Hadart, Blockley, Bardo and Arizona (Figure 2). Using the larger data set for the period 2000-2005, the trend was similar to 2004 data with the following distribution: Typhimurium (42.6 percent), Arizona (9.9 percent), Dublin (8.9 percent) and unknowns (18.5 percent) of the cases. Other serotypes were Senftenberg, Muenster, Mbandaka, Kentucky, Heidlebert, Hadart, Blockley, Bardo, Arizona, Dublin and Derby (Figure 3).

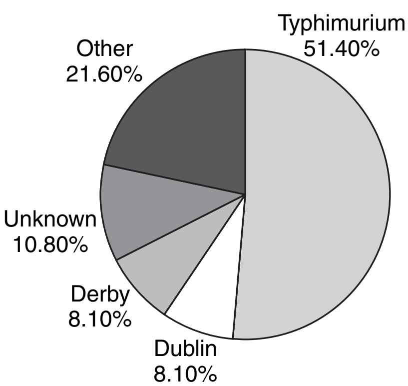

Figure 2. ***Salmonella*** **serotypes isolated from the NDSU VLD in 2004 (N= 37).**

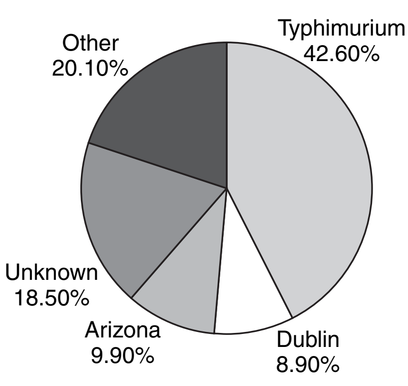

Figure 3. ***Salmonella*** **serotypes isolated from the NDSU VLD in 2000-2005 (N=303).**

Salmonellosis cases from the NDSU-VDL by county: Out of the 37 cases from North Dakota, Minnesota and South Dakota, 16 salmonellosis cases were diagnosed from 11 of the 53 counties in North Dakota in 2004. More than half of the cases (N=nine, 56.3 percent) came from four of the counties - Stutsman (N=three, 18.8 percent), Stark (N=two, 12.5 percent), Richland (N=two, 12.5 percent) and McIntosh (N=two, 12.5 percent) (Figure 4).

NDSU-VDL Salmonellosis cases by time: Data from 2004 showed that of the 37 salmonellosis cases, the majority (10, 27 percent) occurred in March, while the others were in September (five, 13.5 percent), August (four, 10.8 percent) and April (four, 10.8 percent) (Figure 5). The 2000-2005 data showed that of the 303 cases, March again was the month with the highest number of cases at 42 (13.9 percent) and April next highest with 35 (11.6 percent) (Figure 6). Seasonal data showed that of the 37 cases, 14 (37.8 percent) of them were in the spring (March 22- June 21), while summer (June 22- Sept. 23) had 11 cases (29.7

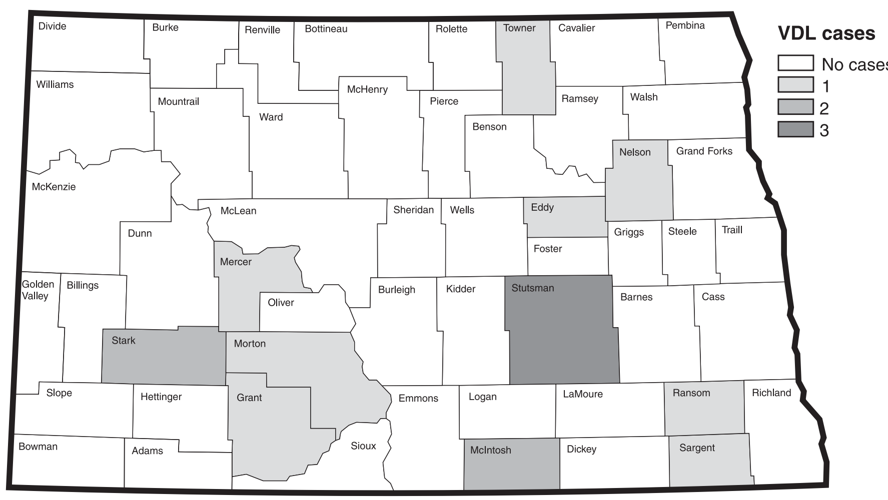

Figure 4. Geographic distribution (by county) of ***Salmonella*** **recovered from submissions to the NDSU-VDL, 2004 (N=16).**

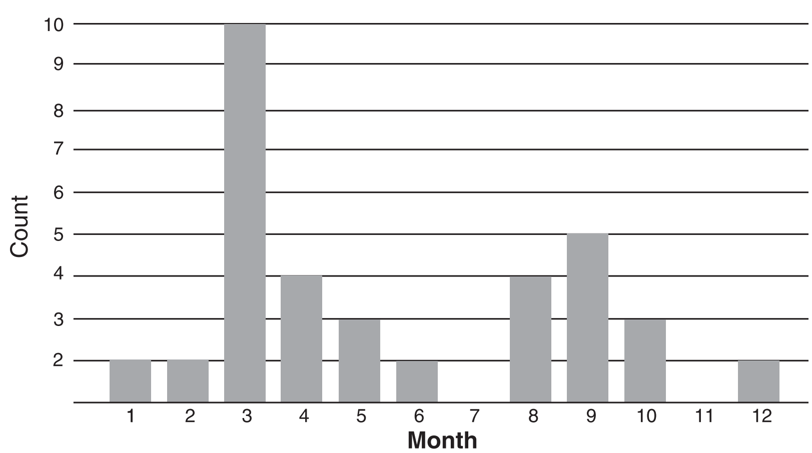

Figure 5. Salmonellosis cases diagnosed at the NDSU-VDL by month, 2004 (N=37).

percent), winter (Dec. 21- March 21) had 7 (18.9 percent) and fall (Sept. 24- Dec 20) had five (13.5 percent) (Figure 7).

The 2000-2005 data analysis showed that of the 303 cases, spring again had the highest total at 102 (33.7 percent) and summer was next with 79 (26.1 percent), followed by winter with 78 (25.7 percent) and fall with 44 (14.5 percent) (Figure 8).

Discussion

Our study indicated a prevalence of *Salmonella* in cattle of 7.1 percent. Other researchers (Dargatz et al., 2000) have reported a lower prevalence (1.4 percent to 4.5 percent) than what we observed, while others (Fegan et al., 2004) have reported the prevalence as high as 16 percent. Our lower prevalence possibly could have been attributed to the smaller sample (N =212) of cattle, compared with that of other researchers. The time of sampling also may have influenced the prevalence of *Salmonella* reported. Seasonal changes have been reported to affect *Salmonella* prevalence. Samples collected during the period of April to June and July to September were more likely to be positive than those collected during October to December and January to March (Fegan et al., 2004). In this study, we sampled cattle from September to November 2004.

The *Salmonella* serotypes identified in beef cattle were *Salmonella* Typhimurium (Copenhagen) (87 percent) and *Salmonella* Worthington (13 percent), while the three major serotypes in NDSU-VDL data accounting for 67 percent of infections were Typhimurium (51 percent), Dublin (8 percent) and Derby (8 percent). The presence of S. Typhimurium in cattle and the consequent cross-contamination of beef carcass tissue are of particular concern as this serotype is one of the most common causes of *Salmonella* infection in developed

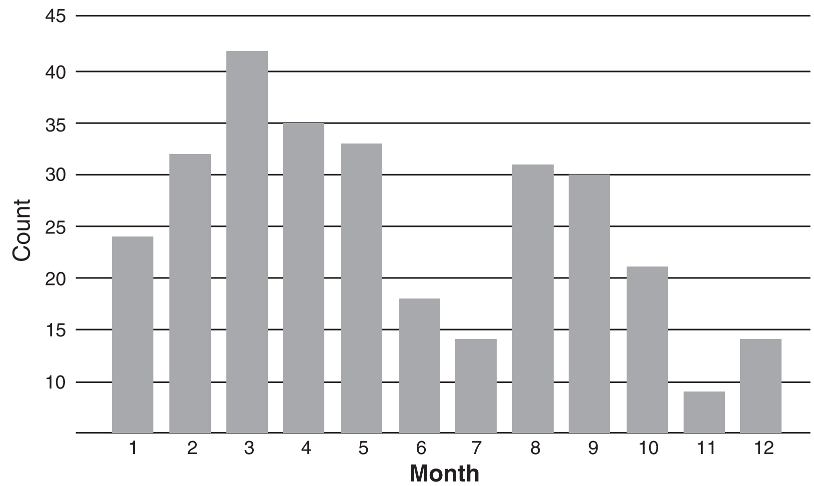

Figure 6. Salmonellosis cases diagnosed at the NDSU-VDL by month, 2000-2005 (N=303).

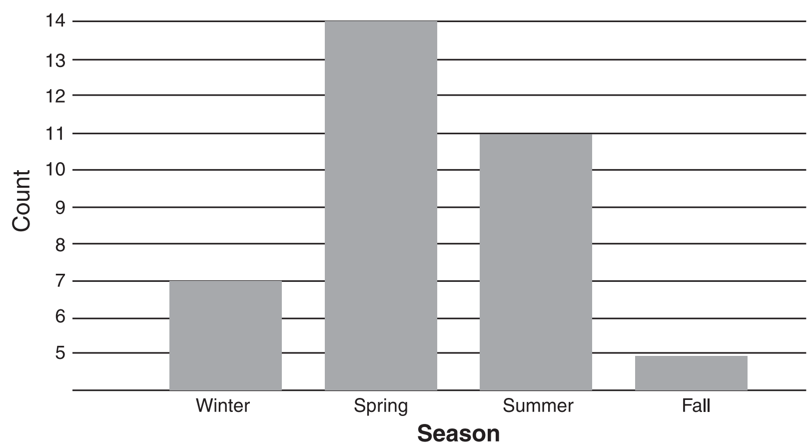

Figure 7. Salmonellosis cases diagnosed at the NDSU-VDL by season, 2004 (N=37).

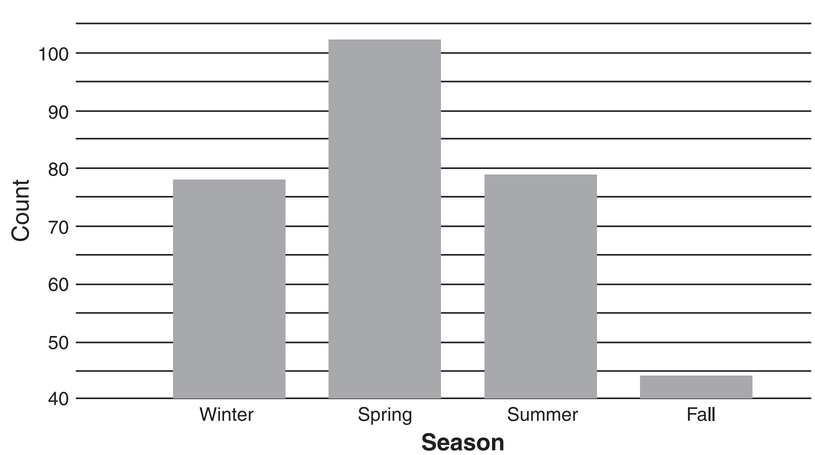

Figure 8. Salmonellosis cases diagnosed at the NDSU-VDL by season, 2000-2005 (N=303).

countries (Gomez et al., 1997). Of the 20 most common *Salmonella* serotypes identified by the Centers for Disease Control and Prevention (CDC), eight (*Salmonella* Typhimurium, Heidelberg, Agona, Montevideo, Braenderup, Enteritidis, Saint Paul and Thompson) are found in both human and nonclinical nonhuman isolates (Chen et al., 2004). All 15 *Salmonella* isolates recovered were resistant to more than 10 antimicrobials, which is an indication that multiple antimicrobial resistance was widespread. This should be of concern because of the potential for therapeutic failures. Other studies have found various levels of antimicrobial resistance. For example, one study of *Salmonella* isolates in food animals found that of the 209 *Salmonella* isolates tested, 112 (53.6 percent) were resistant to more than one antimicrobial (Johnson et al., 2005).

AMR has been a topic of interest in many studies and the results of those studies vary widely. For instance, one study of AMR patterns of *Salmonella* isolated from beef cattle (Dargatz et al., 2000) showed that all of the 1,314 *Salmonella* isolates tested were susceptible to amikacin, cefotaxime and ciprofloxacin, with only 14 percent susceptible to all antimicrobials tested. The remaining 86 percent showed resistance to at least one antimicrobial agent. The most common resistance observed was to tetracycline with ampicillin, and co-amoxiclav was the second most common class to which the *Salmonella* serotypes were resistant.

According to NDSU-VDL records, March had the largest percentage of cases (27 percent) in 2004. This was true for both 2005 data and the 2000-2005 data, where March and August tied for the highest number of cases. This distribution is consistent with other reports (Guerin et al., 2005). When we analyzed NDSU-VDL data by season, we also found that spring was the most common season for *Salmonella* infection in both the 2004 and 2000-2005 data sets.

Conclusions

- Prevalence of *Salmonella* in forage-fed cattle in North Dakota was 7.1 percent, which is relatively higher than some studies have reported.

- *Salmonella* Typhimurium was the most common cause of salmonellosis in animals in North Dakota. The *Salmonella* Typhimurium (Copenhagen) serotype was identified as the major serotype that was being shed by beef cattle.

- The data from this study indicate that some AMR exhibited by clinical isolates was toward similar antimicrobials as those shown by isolates from healthy cattle. This should be of concern because of the potential for therapeutic failures. The emergence of multidrug-resistant *Salmonella* reduces the therapeutic options in cases of invasive infections and has been shown to be associated with an increased burden of illness.

- The data show that multidrug resistance was widespread among the *Salmonella* recovered from apparently healthy forage-fed cattle and also from NDSU-VDL clinical salmonellosis cases, justifying the need for continued surveillance of this organism at multiple levels.

Acknowldgements

The authors thank the North Dakota State University Veterinary Diagnostic Laboratory and North Dakota producers for participating in the study, and the National Veterinary Services Laboratories at Ames, Iowa, for serotyping Salmonella isolates. Funding for this project was provided by a USDA-APHIS special research grant - Biosecurity, Disease Surveillance and Food Safety.

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Profitable calf backgrounding integrating annual forage crops

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This study investigated the impacts of 'Willow Creek' winter wheat, barley and oat cereals harvested as silage and hay on calf backgrounding performance. The data suggests calves consuming barley silage had improved growth and performance, compared with steers consuming the dry-hay treatments. 'Willow Creek' winter wheat shows promise as a calf backgrounding forage.

Introduction

In this four-state region (Montana, North Dakota, South Dakota and Wyoming), cereal forages have become an increasingly important crop to livestock producers. Few statistics are available, but cereal hays are harvested on more than 500,000 acres in this region. One explanation for the popularity of cereal forages may be the current drought conditions and the forages' use as an emergency hay crop.

Small grains (barley, oat, wheat, triticale and rye) are used in crop rotations to renovate alfalfa stands and are an effective way to reduce costs associated with weed and disease control. Cereal hays are a significant source of winter forage for livestock producers in this area. Cereal forages are widely adapted and can be an inexpensive, readily available feed source, with similar harvesting costs as legumes (Helsel and Thomas, 1987). Some advantages of winter cereals, compared with spring cereals, are: greater herbage yields, seasonal distribution of workload and water use efficiency. They have the potential to serve as dual-purpose crops — as both grain and forage.

Previous research has shown differences in feeding value among cereal forage species and across maturity stages at harvest. Some cereal grain seed heads contain rough awns. Awns can affect palatability and cause mouth irritation in livestock. New cultivar development has focused on awn absence or biomass production and not animal feeding performance. This study was designed to evaluate the following objectives: obtain animal performance comparisons of steers consuming a new awnletted (short awns) winter wheat, oat and barley cereal forages; and demonstrate animal performance for a new awnletted winter wheat cultivar.

Procedures

A backgrounding performance study was conducted using 80 purchased crossbred weaned steer calves with initial body weight (BW) of 678 ± 8.4 lbs. Calves were stratified by BW, randomly allotted to one of 16 pens (five steers/pen) and assigned to one of four cereal forage dietary treatments: 1) barley harvested as hay (BH; cv. 'Robust'); 2) barley harvested as silage (BS; cv. 'Robust'); 3) oat harvested as hay (OH; cv. 'Loyal') and 4) winter wheat harvested as hay (WH; cv. 'Willow Creek').

Montana State University in Bozeman developed this awnletted winter wheat. Barley hay, BS and OH harvests were conducted at the same stage of maturity (soft dough stage) during June and July 2005. A commercial farmer grew the WH cultivar near Miles City, Mont., harvested it at flowering and delivered it to the Hettinger Research Extension Center prior to the start of the trial.

At processing, calves were vaccinated twice with Pyramid® 5 MLV vaccine (Fort Dodge, Fort Dodge, Iowa) and

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Ultrabac® 7 clostridial vaccine (Pfizer, Exton, Pa), vaccinated once with One Shot® for Pasturella (Pfizer, Exton, Pa.) and poured with Dectomax® (Pfizer, Exton, Pa.) for internal and external parasites. Calves were implanted with a Ralgro® implant (Schering-Plough, Kenilworth, N.J.) at the beginning of the study.

Steers were fed once daily (9 a.m.), based on pen bunk calls, and given unlimited access to their diets: fresh water, a roughage source, approximately 8 pounds of rolled barley grain and 1 pound of commercial supplement (30 percent crude protein) containing Rumensin®. Deccox® (Alpharma, Fort Lee, N.J.) medicated crumbles were fed during the study for coccidiosis prevention. A commercial hay processor chopped all hays prior to feeding. Two-day unshrunk weights were recorded on day 0, 28 and 57. Diet, feed refusals and fecal samples also were collected on day 0, 28, and 57. Diet samples were collected by pen, combined by respective treatment and analyzed for dry matter (DM), organic matter (OM), nitrogen (N), neutral detergent fiber (NDF) and acid detergent fiber (ADF).

Results and Discussion

Dietary treatment nutrient compositions are displayed in Table 1. In this study, BS had the highest crude protein (CP), net energy gain (NE_g) and OM and the lowest NDF and ADF, with BH and WH being intermediate, and OH having the lowest CP, NE_g, and OM and highest NDF and ADF levels of the dietary treatments (Table 1). High ash content indicates the likelihood the OH diet in this study was contaminated with soil, which resulted in elevated ADF and NDF levels. Previous agronomic research has shown that the chemical compositions of forages are affected by a variety of factors, such as species, varieties within species and stage of growth or maturity, as well as environmental conditions. The diets in this study were formulated to achieve a 2.60-pound average daily gain (ADG); however, the BS treatment had higher NEg values during the feeding trial, compared with the other three dietary treatments, which resulted in higher total and average daily gains (Tables 1 and 2). Although the BS diet had the lowest percentage of rolled barley grain in the total diet, BS forage had higher starch content (greater grain-to-forage ratio) at harvest from seed head fill, compared with the other three forages, thus increasing the diet's overall energy content (Table 1).

Steers consuming BH and BS had similar final weights; however, steers consuming BS had higher final weights, compared with the steers fed OH and WH ($P < 0.10$). Both total gain and ADG were influenced by dietary treatments ($P \leq 0.01$). Calves consuming the BS diet had the highest total gain and ADG of all four treatments, with no difference among BH-, OH- and WH-fed steers ($P > 0.10$). Dry matter intake (DMI) was not affected by treatment ($P = 0.31$) and averaged 2.56 percent of body weight; however, BH steers had DMI that was numerically higher than steers in the other three treatments. Gain-to-feed ratios were the highest for BS steers ($P = 0.02$), compared with the OH, BH and WH steers.

The influence of forage source on dietary intake, diet digestibility and digestible intake is summarized in Table 3. Barley silage had the highest N and lowest ADF and NDF intakes, compared with the dry-hay diets (BH, OH and WH; $P < 0.05$). Barley silage had the highest DM, OM and N digestible intakes and the lowest ADF digestible intake, compared with the other three treatments ($P = 0.02$). In this study, N intake appears to have had the greatest impact on animal performance (total gain and ADG; $P < 0.005$) with these cereal forage treatments.

Table 1. Dietary ingredient and nutrient compositions of diets fed to crossbred steer calves (DM basis).

	Diets			
Ingredient	Barley Silage	Barley Hay	Oat Hay	Wheat Hay
Barley silage, %	63.30	---	---	---
Barley hay, %	---	56.08	---	---
Oat hay, %	---	---	54.30	---
Wheat hay, %	---	---	---	58.75
Barley grain, %	31.48	37.67	39.22	35.38
30% CP supplement[a], %	4.02	4.82	5.01	4.52
Deccox medicated crumbles, %	1.2	1.43	1.49	1.35
Nutrient Concentration				
DM, %	58.2	84.5	83.8	87.7
CP, %	13.6	12.4	9.56	11.2
NE_m , Mcal/lb	0.76	0.62	0.53	0.72
NE_g, , Mcal/lb	0.50	0.36	0.27	0.45
OM, %	89.8	78.1	71.6	85.2
NDF, %	30.6	39.1	62.4	46.2
ADF, %	18.0	24.7	46	26.2
Ca, %	1.24	1.02	0.93	0.71
P, %	0.4	0.3	0.28	0.3
Nitrate, ppm	900	400	500	300
Deccox®, mg/hd/d	170	170	170	170
Rumensin®, mg/hd/d	213	213	213	213

[a]30% Commercial supplement (as fed): 29.0% CP, Ca 17.0%, P 0.45%, K 1.2%, Mg 0.7%,Vitamin A 110,000 IU/kg, Vitamin D3 11,000 IU/kg, Vitamin E 330 IU/kg, Cu 550 ppm, Zn 930 ppm and Mn 1,000

During the study, steers on all three dry-hay diets had large amounts of fines in their feed bunks during feed refusal collections, compared with the BS steers (data not reported). The BS steers did not appear to have sorted as much and apparently consumed a more consistent portion of their total daily feed allotment, compared with steers on the other three treatments, thus improving the BS steers' gain and overall feed efficiency.

Implications

In this backgrounding study, barley silage demonstrated greater potential as a backgrounding feed, compared with the dry-hay treatments (BH, OH and WH). 'Willow Creek' winter wheat shows promise as a possible forage option in calf backgrounding rations. Utilizing cereal grains as forage crops in calf backgrounding rations offers unique business opportunities to producers in this region, especially in periods of drought.

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Table 2. The influence of forage source on backgrounding steer performance.

	Treatments[a]					
Item	**BH**	**BS**	**OH**	**WH**	**SEM**	***P* value[b]**
Initial wt, lbs	686	674	674	677	8.4	0.74
Final wt, lbs	844	858	824	820	11.6	0.07
Total gain, lbs	159	183	150	143	7.02	≤ 0.01
ADG, lbs/d	2.78	3.22	2.63	2.51	0.122	≤ 0.01
Gain: feed, lbs/lbs	0.138	0.17	0.135	0.135	0.009	0.02
Feed intake as % BW	2.66	2.48	2.65	2.44	0.097	0.31

[a]BH = Barley Hay; BS = Barley Silage; OH = Oat Hay; WH = Awnletted Winter Wheat Hay.
[b]*P* value for *F*-test of treatment.

Table 3. The influence of forage source on dietary intake, diet digestibility and digestible intake.

	Treatments[a]					
Item	**BH**	**BS**	**OH**	**WH**	**SEM**	***P* value[b]**
Dietary intake, lbs/d						
DM	19.4	19.1	19.5	19.3	0.94	0.99
OM	14.8	15.8	15.2	14.8	0.80	0.78
N	0.35	0.39	0.32	0.32	0.017	0.03
ADF	5.92	4.45	6.11	6.72	0.356	< 0.01
NDF	9.92	8.12	10.0	10.64	0.575	< 0.05
Diet digestibility, %						
DM	41.7	57.1	50.0	48.0	1.50	< 0.005
OM	41.5	59.6	51.4	48.1	2.06	< 0.005
N	25.2	52.0	40.3	37.5	2.45	< 0.005
ADF	29.5	26.5	28.6	31.9	1.88	0.29
NDF	37.0	42.8	39.9	41.4	1.74	0.17
Digestible intake, lbs/d						
DM	8.09	10.92	9.77	9.25	0.52	0.02
OM	6.12	9.42	7.87	7.09	0.53	< 0.01
N	0.09	0.21	0.13	0.12	0.009	< 0.005
ADF	1.75	1.19	1.76	2.14	0.168	0.013
NDF	3.67	3.49	4.03	4.39	0.302	0.214

[a]BH = Barley Hay; BS = Barley Silage; OH = Oat Hay; WH = Awnletted Winter Wheat Hay.
[b]*P* value for *F*-test of treatment.

Effects of field pea inclusion on ruminal fermentation and digestion in steers fed high-concentrate finishing diets

B.A. Stoltenow[1], G.P. Lardy[1], M.L. Bauer[1], T.C. Gilbery[1] and V.L. Anderson[2]

The objective of this study was to evaluate the effects of field pea inclusion on ruminal fermentation and digestibility in steers fed high-concentrate finishing diets. While intake increased, digestibility was not affected with increasing levels of field pea, indicating field pea to be a suitable replacement for corn in high-concentrate diets.

Summary

Four Angus steers (1,280 ± 90 pounds initial body weight) fitted with ruminal and duodenal cannulas were used in a 4 by 4 Latin square-designed experiment to test the effect of field pea inclusion in high-concentrate diets on intake, ruminal fermentation and site of digestion. Field pea replaced portions of urea, soybean meal and corn at 10 percent, 20 percent and 30 percent of dietary dry matter to formulate the dietary treatments. Dry matter intake (DMI) and organic matter (OM) intake increased as peas increased in the diet ($P \leq 0.05$). Field pea grain appears to be a suitable replacement for combinations of corn, soybean meal and urea in high-concentrate finishing diets.

Introduction

Field pea *(Pisum sativum)* acreage has increased in North Dakota since 1998. North Dakota leads the nation in field pea production, with 590,000 acres harvested in 2006 (NASS, 2007). Field pea can be used as both a protein and energy source for cattle, containing 25 percent crude protein (CP) and 87 percent total digestible nutrients (TDN; NRC, 1984). Thus, the feed industry is an excellent potential market for field pea. Previous research indicates DMI increases when field pea replaced corn in diets for growing steers (Reed et al., 2004). Similar feed conversion efficiency and weight gains have been reported when comparing field pea to hull-less oat (Poland and Landblom, 1996). Field pea has been included successfully in lamb finishing diets up to 45 percent of the diet (Loe et al., 2004). In a companion study to this experiment, no differences were found in DMI, average daily gain and gain efficiency when steers were fed high-concentrate diets containing up to 30 percent field pea (Larson et al., 2007). However, no research has been conducted that investigates the effect of field pea inclusion on ruminal fermentation and digestibility when included in high-concentrate diets fed to steers.

Procedures

Four ruminally and duodenally cannulated Angus steers were used in a 4 by 4 Latin square to evaluate the effects of field pea inclusion on DMI, ruminal fermentation and site of digestion. Steers were housed in an enclosed barn in individual stanchions (4 feet by 7 feet) on rubber mats. Steers were allowed free access to water and were fed a total mixed ration twice daily at 7 a.m. and 7 p.m.. Diets were offered to ensure an ad libitum intakes plus 10 percent refusal. The control diet on a dry matter (DM) basis consisted of 79.75 percent corn, 5 percent corn silage, 5 percent alfalfa, 5 percent concentrated separated byproduct and 5.25 percent supplement (Table 1). Treatments consisted of (DM basis): 1) control, containing no field pea, 2) 10 percent inclusion of field pea, 3) 20 percent inclusion of field pea and 4) 30 percent inclusion of field

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pea. Diets were formulated to contain a minimum of 13 percent CP, 0.70 percent calcium (Ca) and 0.29 percent phosphorus (P). Diets also contained 25 grams per ton (g/T) Rumensin and 10 g/T Tylan.

Each period was 14 days in length, with nine days of adaptation and five days of sample collection. Individual feed and complete diets were sampled and analyzed for nutrient content. Feed refusals were measured daily. Total fecal output was measured to determine total tract digestion. Intestinal samples were taken between days 11 and 13 of collection to estimate site (ruminal vs. intestinal) of digestion. Ruminal fluid samples were collected on day 14 to determine ammonia (NH_3) , volatile fatty acids and pH.

Results

A summary of the results are found in Table 2. Dry-matter intake increased ($P \leq 0.05$) as field pea level increased in the diets. Similarly, OM intake increased as field pea level increased ($P = 0.03$); however, the treatments had no effect on total tract OM digestibility ($P = 0.64$; 74.4 ± 2.7 percent). Total tract CP digestion ($P = 0.31$; 60.9 ± 3.9 percent) was not affected by treatment ($P = 0.31$). Microbial efficiency did not differ among treatments ($P = 0.77$; 0.08 ± 0.02 g microbial N/kg OM digested ruminally).

Neutral detergent fiber ($P = 0.21$; 5.3 ± 0.1 pound/day) and acid detergent fiber (ADF) ($P = 0.27$; 2.1 ± 0.1 pound/day) intake did not differ with increasing levels of field pea (data not shown). Total tract neutral detergent fiber (NDF) digestibility was not different among treatments ($P = 0.21$; 63.2 ± 3.7 percent digestibility). Total tract ADF digestibility tended to increase ($P = 0.10$; 49.8, 56.0, 62.3, and 65.6 ± 4.6 percent digestibility, respectively for 0 percent, 10 percent, 20 percent and 30 percent field pea inclusion) with increasing field pea inclusion.

Ruminal pH was not affected ($P = 0.24$; 6.28 ± 0.06) by increasing field pea inclusion. A quadratic change was measured in ruminal ammonia ($P = 0.004$) due to increased field pea levels. Total volatile fatty acid (VFA) tended ($P = 0.07$) to change quadratically with increasing levels of field pea. However, molar proportions of acetate (49.6 ± 1.4 percent), propionate (28.9 ± 2.4 percent) and butyrate (12.8 ± 2.1 percent) were not affected ($P \geq 0.60$) by treatments.

Implications

Field pea inclusion increased DMI without affecting OM or CP digestibility or ruminal fermentation parameters. Therefore, these data suggest that field pea is a suitable substitution for corn in high-concentrate diets for finishing steers.

Table 1. Composition and analyzed dietary nutrient content of diets fed to beef steers.

	Dietary field pea, %			
Item	**0**	**10**	**20**	**30**
Ingredient, % DM[a]				
Dry-rolled corn	79.75	70.75	61.75	52.75
Rolled field pea	0.00	10.00	20.00	30.00
Corn silage	5.00	5.00	5.00	5.00
Alfalfa hay	5.00	5.00	5.00	5.00
CSB	5.00	5.00	5.00	5.00
Supplement	5.25	4.25	3.25	2.25
Analyzed dietary nutrient content, %				
DM, %	85.5	85.8	86.0	86.3
	------------------- % of DM -------------------			
OM, %	91.1	91.5	92.1	91.4
CP, %	13.2	12.5	11.9	12.5
NDF, %	18.2	18.0	18.8	19.0
ADF, %	7.0	7.0	7.4	7.5

[a]Diets were formulated to contain 25 g/T Rumensin and 10 g/T Tylan and a minimum of 13% CP, 0.70% Ca and 0.28% P.

Table 2. Effect of field peas on OM digestion, CP digestion, ruminal pH, total VFA and ammonia concentrations in steers.

	Dietary field pea					Treatment	Contrasts[a]		
Item	**0**	**10**	**20**	**30**	**SEM**	***P*-value**	**L**	**Q**	**C**
OM digestion, % of intake									
True ruminal	31.8	33.5	37.4	36.4	7.5	0.95	0.63	0.86	0.85
Intestinal	61.4	61.7	51.6	64.2	9.1	0.76	0.97	0.51	0.43
Total tract	74.6	72.0	76.0	75.0	2.7	0.64	0.61	0.72	0.28
CP digestion, % of intake									
Total tract	62.2	64.9	55.8	60.8	2.9	0.31	0.38	0.72	0.11
Ruminal pH	6.3	6.3	6.3	6.2	0.05	0.24	0.06	0.82	0.67
Ruminal NH_3, mM	6.3	5.4	4.7	9.6	0.58	0.004	0.01	0.003	0.08
Total VFA, mM	117.4	113.6	118.3	129.1	3.3	0.65	0.34	0.07	0.88

[a]Contrasts were L = linear, Q = quadratic, and C = cubic.

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Effect of an SNP in the bovine leptin gene on the growth and carcass characteristics of growing and finishing beef cattle

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The objectives of this study were to determine the effects of a genetic variation (cytosine to thymine, exon 2) in the bovine leptin gene on growth and carcass characteristics in beef steers. Three genotypic variants — CC, CT and TT — were possible at this locus. Genotype did not affect initial or final body weight or average daily gain (ADG). However, TT had greater 12th rib fat at day 0 and at slaughter, compared with CT and CC. At slaughter, longisimus (LM) area was greater for CC than CT or TT. The TT calves had greater yield grades when compared with CT or CC. Marbling score was unaffected by genotype.

Introduction

An individual's potential to accrete fat and muscle is determined in part by the animal's genetic composition. Interest is increasing in identifying single nucleotide polymorphisms (SNP) that help explain genetic differences that cause phenotypic changes in economically relevant traits. A DNA strand is composed of four nitrogenous bases. It is the particular sequence of these nitrogenous bases that direct the synthesis of a specific protein. However, single-base changes or SNPs may alter the production or activity of the protein.

One such protein is the hormone leptin. Leptin is produced primarily in adipose tissue and serves as a signal of body fatness. A SNP was discovered in the bovine leptin gene (Buchanan et al., 2002). This SNP is a single-base substitution, where cytosine (C) is replaced by thymine (T). This resulted in the TT homozygotes having greater carcass fat.

Buchanan et al. (2002) found that British breeds of cattle have a higher incidence of the T allele when compared with Continental breeds of cattle. At a constant carcass weight, T homozygotes had higher marbling scores and greater 12th rib fat depth (Bierman et al., 2003). In subsequent studies, the T homozygotes were found to have a greater 12th rib fat depth, greater yield grade and more lean meat yield (Nkrumah et al., 2005; Schenkel et al. 2005). However, these studies indicated that this polymorphism did not have a significant effect on marbling. Kononoff et al. (2005) found that T homozygotes tended to have higher quality grades than C homozygotes. In addition, the C homozygotes had a lower percentage of cattle with a yield grade of one when compared to T homozygotes.

Here we analyzed three genotypic variants — the CC, CT and TT genotypes. Genotype did not affect initial or final weight or ADG. However, TT had greater 12th rib fat initially and at slaughter, compared with CT and CC. At slaughter, LM area was greater for CC than CT or TT. The TT calves had greater yield grades when compared with CT or CC. Marbling was unaffected by genotype.

Material and Methods

Two experiments were conducted at a commercial feedlot. Experiment 1 was conducted in 2003-2004. One hundred eighty-nine crossbred beef steer calves with an initial weight of 613 ± 18 pounds were obtained from two separate sale barns. Blood samples were collected and genomic DNA was analyzed to determine which form of the SNP was expressed. Synovex S (Fort Dodge, Overland Park, Kan.) was administered upon arrival and weight was measured.

Subsequently, steers were weighed on days 71 and 160. Calves also were reimplanted on day 71 with Synovex S. Real-time ultrasonography, per-

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formed by a certified technician, was used to measure LM area and fat depth between the 12th and 13th ribs on days 0 and 160. Twelfth rib fat also was analyzed ultrasonically on days 74 and 89.

Steers were fed a common diet in a common pen. Steers were fed a receiving diet for approximately 30 days, a growing diet for approximately 90 days and a finishing diet for the remaining days on feed.

Calves were slaughtered on one of four dates at day 176, 182, 190 or 197. Final weight was calculated using hot carcass weight and a common dressing percentage of 62.5 percent and a common shrink of 4 percent. From these data, an overall ADG was calculated.

Experiment 2 was conducted during 2004-2005. Three hundred ninety-two crossbred steer and heifer calves (predominantly Angus) from a single source and 230 crossbred heifer calves (predominately continental) from a sale barn with an initial weight of 615 ± 19 pounds were fed a diet similar to experiment 1. Blood samples were collected and genomic DNA was extracted and analyzed as described in experiment 1. Weight and ultrasonic measurements of 12th rib fat were taken on days 0, 56, 92 and 138. In addition, LM area was measured on days 0 and 92. Ultrasonic measurements were performed as described for experiment 1.

The implant program was administered as described in experiment 1. Finally, the incidence of disease was recorded for each calf for future use in removing the effect of morbidity on performance and carcass characteristics. Calves were slaughtered on one of four dates at day 150, 178, 179 or 198.

The data were analyzed for the presence of year by genotype interactions. None were found; therefore, the data from both experiments were combined and presented as such. Feedlot performance and carcass data were analyzed using the mixed procedure of SAS. In addition, the distribution of carcass quality and yield grade was analyzed using the frequency procedure of SAS.

Results

The effect of genotype on feedlot performance, ultrasound and carcass 12th rib fat and LM area is presented in Table 1. Initial weight tended (P = 0.07) to favor the T homozygotes over the CT heterozygotes and C homozygotes. However, final weight (1,243 ± 8 pounds; (P = 0.60) and ADG (3.40 ± 0.02 pounds/day; (P = 0.59) were not different between genotypes. This may indicate a preweaning advantage for the T homozygotes over the other genotypes; however, that difference was not maintained throughout the study. Though significant, genotype only explained 0.36 percent of the variation in initial weight. The T homozygotes (188.0 ± 1.1 days) also tended ((P = 0.07) to be fed for fewer days, when compared with CT heterozygotes (190.5 ± 0.7 day) and C homozygotes (191.3 ± 1.2 days).

Initial 12th rib fat was greater ((P = 0.03) in T homozygotes, when compared with CT heterozygotes and C homozygotes. The T homozygotes also had greater ((P = 0.001) final carcass 12th rib fat, when compared with the CT heterozygotes and C homozygotes, and this SNP explained 2.1 percent of the total variation in 12th rib fat. Numerous studies have indicated that T homozygotes have greater 12th rib fat (Bierman et al., 2004; Schenkel et al., 2005), compared with C homozygotes.

No difference ((P = 0.40) were found between genotypes on day 0 for LM area (7.96 ± 0.08 in^2). However, final carcass LM area was lower ((P = 0.01) for T homozygotes, compared with CT heterozygotes and C homozygotes.

Table 1. Effect of genotype on feedlot performance and ultrasound and carcass 12th rib fat and LM area.

	Genotype					Mean Separation		
Item	CC	CT	TT	SEM[1]	P	CC vs. CT	CC vs. TT	CT vs. TT
n	169	423	214					
Weight, lb								
Initial	597	601	612	5	0.07	0.60	0.04	0.05
Final	1243	1241	1249	8	0.60	0.83	0.53	0.32
ADG, lb/d	3.42	3.37	3.37	0.02	0.59	0.40	0.33	0.76
Days on feed, d	191.3	190.5	188.0	1.2	0.08	0.82	0.10	0.14
12th rib fat, in								
Initial	0.11	0.11	0.12	0.003	0.03	0.82	0.03	0.01
Final	0.49	0.51	0.55	0.01	0.001	0.22	<0.001	0.001
Change from initial	0.38	0.40	0.43	0.01	0.01	0.20	0.001	0.18
LM area, in^2								
Initial	7.98	7.89	8.00	0.08	0.40	0.35	0.87	0.23
Final	13.01	12.89	12.60	0.11	0.01	0.37	0.01	0.02
Change from initial	5.03	5.00	4.60	0.11	0.001	0.80	0.001	<0.001

[1]SEM where n = 169.

This SNP explains 2.6 percent of the total variation in LM area.

The effect of genotype on carcass characteristics is presented in Table 2. Hot carcass weight (753 ± 5 pounds) was not different ($P = 0.60$) among genotypes. The percentage of kidney, pelvic and heart (KPH) fat tended ($P = 0.10$) to be greater for CT heterozygotes, when compared with C homozygotes. Marbling score (450 ± 7) was not different ($P = 0.14$) between genotypes. However, the T homozygotes tended (χ^2 P = 0.09) to have a greater percentage of calves (31.3 percent) with modest^0 marbling (average Choice) or above when compared with the C homozygotes (22 percent).

Yield grade is an accurate predictor of lean meat yield of a carcass. The T homozygotes had greater ($P < 0.001$) yield grades than did the CT heterozygotes and C homozygotes. In this data set, this SNP explained 4.7 percent of the total variation in yield grade, which is impressive for a single polymorphism. In addition, the C homozygotes had a greater percentage (χ^2; $P \leq 0.001$) of calves with a Yield Grade of 1 and 2 (60.7 percent), when compared with the T homozygotes (33.7 percent).

The ratio of marbling to measures of adiposity may indicate differential effects of the SNP on fat deposition sites. The ratio of marbling to 12th rib fat indicates that T homozygotes have less marbling ($P = 0.01$) than do the CT heterozygotes and C homozygotes per unit of 12th rib fat. The marbling-to-yield grade ratio, while indicating differential effects on adipose deposition, is also economically important. Once again, the C homozygotes had more marbling ($P = 0.04$) than the T homozygotes per unit of unit of yield grade. This indicates that C homozygotes will have similar marbling scores at lower yield grades, compared with T homozygotes. This may have large economic implications. Many feedlot cattle in the United States are marketed on a grid basis that pays a premium for carcass quality and lean tissue content. If C homozygotes are able to reach a satisfactory quality grade while having lower yield grades, they will be more valuable.

Implications

This SNP has a significant effect on growth rates of and carcass 12th rib fat depth and LM area. As beef cattle are sold based on lean yield and carcass quality, this SNP may prove valuable. Further research is needed to elucidate the functional change caused by this mutation, demonstrate that this SNP is the functional polymorphism and is not linked to another SNP, and quantify the precise effect of this change on animal production.

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Table 2. Effect of leptin SNP genotype on carcass characteristics.

	Genotype					Mean Separation		
Item	CC	CT	TT	SEM[1]	*P*	CC vs. CT	CC vs. TT	CT vs. TT
HCW, lb	752	750	756	5	0.60	0.83	0.53	0.32
Marbling score[2]	444.8	446.3	460.2	6.9	0.14	0.85	0.10	0.06
KPH fat, %	1.97	2.07	2.04	0.04	0.10	0.03	0.24	0.44
Yield grade	2.84	2.94	3.15	0.06	<0.001	0.15	<0.001	<0.001
Marbling:12th rib fat	385.1	380.5	353.5	9.2	0.01	0.67	0.01	0.01
Marbling:yield grade	166.5	163.7	154.4	4.0	0.04	0.55	0.02	0.03

[1]SEM where n = 169.
[2]Where 400 = small^0, and 500 = modest^0.

Dietary field pea effects on feedlot performance, carcass characteristics and beef tenderness in finishing beef steers.

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The objectives of this study were to evaluate the effect of increasing field pea inclusion on the intake, performance and carcass characteristics of finishing steers and to evaluate beef palatability, particularly differences in tenderness. Increasing the level of field pea inclusion did not affect dry-matter intake (DMI), average daily gain (ADG), gain-to-feed ratio (G:F) or calculated dietary net energy gain (NE_g). Carcass characteristics also were similar among all levels of field pea inclusion. Additionally, no differences were found in sensory panel and Warner-Bratzler shear force values

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Introduction

Field pea production in North Dakota is increasing rapidly. Since 2000, production has increased 89 percent to reach a level of 6.1 million bushels per year. North Dakota led the nation in field pea production in 2006 (USDA NASS, 2006). As field pea production increases, a substantial amount is available for livestock consumption. This includes those peas unsuitable for human consumption, such as the splits and brokens. However, interest in raising field pea primarily for livestock consumption is increasing.

Relative to corn, field pea is higher in crude protein. Therefore, they are an attractive feedstuff in many different phases of beef production. Field pea has been incorporated into creep feeding diets. Field pea replacing between 33 percent and 100 percent of wheat midds in a creep diet resulted in increased dry matter (DM) intake and increased daily gain up to 67 percent field pea inclusion (Anderson, 1999a). Feed efficiency declined with increasing field pea inclusion. Gelvin et al. (2004) reported that field pea at 55 percent of the creep feed diet resulted in increased DM intake and no effect on gain or feed efficiency.

Field pea fed to growing steer calves at 60 percent of the DM improved feed efficiency over the barley control (Anderson 1999b). When field pea was included in a growing diet up to 26 percent of the diet, DM intake increased linearly ($P = 0.06$); however, gain and feed efficiency were similar (Fendrick et al., 2005a).

Field pea replaced the barley control and canola meal (76 percent dietary DM) in a finishing diet. The field pea treatment tended ($P < 0.10$) to increase DM intake and ADG. Therefore, gain efficiency was similar among treatments. The field pea-fed group had greater ($P \leq 0.05$) marbling scores and percentage of steers grading Choice in this experiment (Anderson, 1999b). Whole pea was fed at 0 percent, 20 percent, 40 percent and 59 percent of the dry matter to finishing steers (Fendrick et al., 2005b). DM intake increased ($P < 0.01$) up to the 40 percent inclusion level; however; gain efficiency and carcass traits were unaffected ($P >$ 0.10). A finishing diet that included 0 percent, 5 percent, 10 percent or 20 percent field pea resulted in decreased ($P < 0.05$) DM intake with increasing levels of field pea inclusion (Flatt and Stanton, 2000). Gain efficiency and carcass characteristics were unaffected ($P > 0.10$). With finishing lambs, Loe et al. (2004) determined that field pea contains 1.24 and 0.91 megacalories per pound (Mcal/lb) of net energy for maintenance and net energy for gain, respectively. This represents a value approximately 14 percent greater than that of corn. Finally, field pea replaced corn and soybean meal at 0 percent, 10 percent, 20 percent and 30 percent of the dry matter in a study with finishing heifers (Maddock Carlin et al., 2006). No differenced in feedlot performance were noted in this study. However, field pea inclusion resulted in a quadratic decrease (*P* = 0.001) in Warner-Bratzler shear force and a linear increase (*P* = 0.002) in consumer taste panel ratings of tenderness. The objectives of the current study were to determine the effect of increasing the level of field pea (replacing corn and soybean meal at 0 percent, 10 percent, 20 percent and 30 percent of dietary DM) on feedlot performance and carcass characteristics, as well as Warner-Bratzler shear force tenderness and sensory panel ratings for tenderness, juiciness and flavor of resulting steaks.

Material and Methods

One-hundred forty-three crossbred steers were housed at the NDSU animal research center in concrete-floored pens (five to six head/pen). The steers were blocked by initial weight (955 ± 42 pounds) and assigned randomly to one of four dietary treatments. Treatments included field pea replacing 0 percent, 10 percent, 20 percent or 30 percent of the corn and soybean meal in the basal diet. The basal diet DM was composed of 80 percent dry-rolled corn, 5 percent beet pulp, 5 percent mixed grass/legume hay, 5 percent concentrated separator byproduct and 5 percent supplement that provided 27.5 grams per ton (g/T) Rumensin and 11 g/T Tylan. The diets were formulated to provide a minimum of 0.70 percent calcium (Ca) and 0.28 percent phosphorus (P), and provide 13 percent crude protein (CP), with the exception of the 30 percent field pea inclusion treatment. Due to the increased CP content of the field pea, the formulated diet contained 14.2 percent CP.

Initial weight was an average of three consecutive days and subsequently, weight was measured every 28 days. Final weight was computed from hot carcass weight, using a common dressing percentage of 62.5 percent and a common shrink of 4 percent. Feed offered was recorded daily and feed refusal was recorded weekly. Weekly feedstuff samples were collected to determine diet DM and to analyze nutrient composition. Calves were implanted with Synovex Choice on day 0. Carcass data was collected at slaughter. A 7-centimeter (cm) (approximately) portion of longissimus muscle was removed caudally starting from the 12th rib location on the left side of each carcass. Longissimus muscle samples were vacuum-packaged, aged for 14 days at 4 degrees Celsius, cut into two 2.54-cm thick steaks and frozen. One steak was evaluated for Warner-Bratzler shear force (WBSF). Each steak was broiled to an internal temperature of 72 C and allowed to cool to room temperature. Six cores were removed from each steak parallel to the muscle fibers and sheared. The second steak was evaluated by a trained panel for tenderness, juiciness and flavor, using a scale of 1 to 8 (1 = extremely tough, dry and bland; 8 = extremely tender, juicy and intense beef flavor) and for off-flavor, using a scale of 1 to 4 (1 = extreme off flavor, 4 = no off flavor). Data were analyzed with the mixed model of SAS with linear and quadratic contrasts ($P \leq 0.05$).

Results

The effects of field pea inclusion on intake, performance and net energy are shown in Table 1. Final weight (1,296 ± 25 pounds; *P* = 0.80), ADG (4.32 ± 0.11 pound/day; *P* = 0.49) and DM intake (23.74 ± 0.62 pound/day; *P* = 0.44) were not affected by treatment. In addition, feed efficiency (5.49 ± 0.10 pound feed/pound gain; *P* = 0.92) and calculated dietary net energy for gain (69.0 ± 1.8 megacalories per hundredweight, or Mcal/cwt; *P* = 0.74) were similar among treatments. This data is different from that of Loe et al. (2004), who determined that field pea increased dietary net energy when replacing only corn in lamb finishing diets. In this experiment, dietary energy was not different among treatments. Therefore, field pea would have a similar energy to dietary ingredients they replaced; 89.8 percent corn (70.3 Mcal/cwt) and 10.2 percent soybean meal (67.1 Mcal/cwt) for a field pea net energy of gain of 70 Mcal/cwt.

The effects of field pea inclusion on carcass characteristics are presented in Table 2. Hot carcass weight (777 ± 15 pounds; *P* = 0.80), 12th rib fat (0.39 ± 0.02 inch; *P* = 0.51), longisimus area (13.01 ± 0.19 inch^2; *P* = 0.14) and kidney, pelvic and heart fat, or KPH (1.95 ± 0.06 percent; *P* = 0.12) were not different among treatments. In addition, marbling score (394 ± 12; *P* = 0.62) and yield grade (2.66 ± 0.11; *P* = 0.56) were similar between treatments.

The effect of field pea inclusion on carcass characteristics in this study agrees with previous data with one exception. Anderson (1999b) replaced barley with field pea at 76 percent of dietary DM and noted an increase in marbling score and percentage of steers grading Choice. The current study only included field pea up to 30 percent of the DM, similar to much other previous research. Therefore, increasing field pea inclusion above 30 percent of the DM may affect carcass quality.

The effects of field pea inclusion on meat palatability measurements are presented in Table 3. Measurements for WBSF (8.27 ± 2.09 pounds; *P* = 0.12), sensory panel tenderness (5.80 ± 0.32; *P* = 0.53), juiciness (5.43 ± 0.37; *P* = 0.81), flavor (5.65 ± 0.19; *P* = 0.58) or off flavor (3.72 ± 0.10) were not different. The results of this data contradict a previous study (Maddock Carlin et al., 2006), which reported a decrease in Warner-Bratzler shear force and an increase in sensory panel tenderness scores when field pea was included in the ration. The reason why our data differs may be related to differences between the two studies. These differences include the use of implants (moderate potency implants were used in this study, while the cattle in the previous study were not implanted), sex of cattle (steers vs. heifers) and age of cattle at harvest (calf-feds in this study vs. yearlings in the previous work).

Implications

As field pea production in North Dakota increases, a growing volume of excess field pea is available to be used as a feedstuff. These present an attractive alternative to corn, as they may be less costly. In addition, the increased CP concentration of field pea allows for the removal of more expensive protein sources from the diet, further reducing feed costs. These data indicate that replacing corn with field pea up to 30 percent of the dietary DM does not impact feedlot performance, carcass characteristics or palatability of the resulting meat products. Therefore, field pea presents an attractive alternative feed source in North Dakota.

Table 1.Effect of field pea on intake, performance and net energy.

	Field pea level, % DM					
	0	10	20	30	SEM[a]	Lin *P*
Pens	6	6	6	6		
Steers	35	36	36	36		
Final BW, lb	1299	1285	1303	1296	25	0.80
ADG, lb/d	4.32	4.17	4.45	4.34	0.11	0.49
DMI, lb	23.5	23.1	24.7	23.7	0.6	0.44
Dietary NEg, Mcal/cwt	69.85	68.95	67.59	69.40	1.81	0.74
F:G	5.41	5.56	5.56	5.43	0.17	0.92

[a]Standard error of the mean, n = 6.

Table 2.Effect of field pea on carcass characteristics.

	Field pea level, % DM					
	0	10	20	30	SEM[a]	Lin *P*
Hot carcass weight, lb	778	772	780	778	15	0.80
Marbling[b]	389	392	398	395	12	0.62
Ribeye area, in^2	12.59	12.77	13.04	12.93	0.19	0.14
12th rib fat, in	0.38	0.37	0.40	0.39	0.02	0.51
KPH, %	1.90	1.85	2.07	1.96	0.06	0.12
Yield grade	2.73	2.60	2.64	2.65	0.11	0.56

[a]Standard error of the mean, n = 6.
[b]300 = slight^0, 400 = small^0.

Table 3.Effect of field pea on beef palatability.

	Field pea level, % DM					
	0	10	20	30	SEM[a]	Lin *P*
WBSF[b], lb	8.36	7.83	8.62	8.03	2.09	0.12
Sensory panel						
Tenderness	5.76	5.92	5.69	5.92	0.32	0.53
Juiciness	5.34	5.55	5.42	5.41	0.37	0.81
Flavor	5.66	5.74	5.64	5.58	0.19	0.58
Off flavor	3.74	3.72	3.76	5.69	0.10	0.68

[a]Standard error of the mean, n = 6.
[b]Warner-Bratzler shear force

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Discovering value in North Dakota calves: The Dakota Feeder Calf Show Feedout Project V

Progress Report Year 2005-2006

Karl Hoppe[1]

Cow calf producers in North Dakota are determining the value of the calves they produce by measuring feedlot performance and carcass characteristics. The Dakota Feeder Calf Show Feedout project was developed to discover the actual value of spring-born beef steer calves and provide comparisons between herds and benchmark feeding performance.

Cattle consigned to the feedout project averaged 608 pounds upon delivery to the Carrington Research Extension Center Livestock Unit on Oct. 15, 2005. After an average 202-day feeding period with no death loss, cattle averaged 1,249 pounds (at plant, shrunk weight). Average daily feed intake per head, as fed, was 28.3 pounds, while pounds of feed required per pound of gain were 8.9. Diet dry matter was 72.8 percent. The pen-of-three calves averaged 388 days of age at harvest. Overall pen average daily gain was 3.2 pounds. Feed cost was $0.280 per pound and the total cost of gain without interest was $0.462.

The cattle were marketed during a 21-day period and marbling scores averaged 435.1 (low Choice). A marbling score of 400 equals Choice 0. Profit before interest expense ranged from $54.77 per head for pen-of-three cattle with superior grow and carcass traits to a loss of $186.42 per head for poorer performance. The feeding and carcass value of spring-born calves can be determined with participation in a feedout project.

Introduction

Determining calf value is a continuing experience for cow-calf producers. To remain competitive with other livestock and poultry in the meat industry, cow-calf producers need to identify superior genetics. At time of bull selection, a producer also must estimate the type of animal desired by buyers 1½ to two years before sale. Marketplace premiums are provided for calves that have exceptional feedlot performance and produce a high-quality carcass. In addition, superior cost-effective feeding performance is needed to justify the expense of feeding cattle past weaning. Since North Dakota feeds are low cost and the climate is favorable, low feeding cost per pound of gain can be accomplished (Hoppe et al., 1997). This feedlot project was developed to provide cattle producers with an understanding of cattle genetics and cattle feeding in North Dakota.

Materials and Methods

The Dakota Feeder Calf Show was developed for cattle producers willing to consign steer calves to a show and feedout contest. The calves were received in groups of three or four on Oct. 15, 2005, at the Turtle Lake Weighing Station, Turtle Lake, N.D., for weighing, tagging, processing and showing. The calves were evaluated for conformity and uniformity, with the judges discussing the results with the owners at the beginning of the feedout.

The calves then were shipped to the NDSU Carrington Research Extension Center, Carrington, N.D., for feeding. Prior to shipment, calves were treated prophylactically with Tetradure® (oxytetracycline). Calves then were sorted and placed on corn-based receiving diets containing varying inclusions of flax. After a two-week adaptation period, the calves were moved onto a corn-based 80 percent grain diet also containing varying inclusions of flax. Cattle were weighed periodically and reports provided to the owners.

An open house was held on Feb. 6, 2006, at the NDSU Carrington Research Extension Center Livestock Unit, where the owners reviewed the calves and discussed marketing conditions. The calves were given an ultrasound for backfat and marbling on March 15, 2006, and sorted into market groups based on back fat, marbling and live weight. Sorting criteria were U.S. Department of Agriculture Yield Grade 3 Choice cattle with a carcass

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weight less than 950 pounds and level of flax included in the diet.

The first market group of cattle (83 head) was harvested on April 25, 2006. The second sell group (84 head) was harvested on May 16, 2006. Cattle were sold to Tyson Fresh Meats, Dakota City, Neb., on a grid basis with premiums and discounts. Carcass data was collected after harvest.

Ranking in the pen-of-three competition was based on the best score obtained. Overall score was determined by adding the index score for weight per day of age (20 percent of score), average daily gain on test (20 percent of score), marbling score (20 percent of score) and retail product value divided by weight per day of age (40 percent of score). The Dakota Feeder Calf Show provided cash awards for the top placing pens of steers.

Results and Discussion

Cattle consigned to the Dakota Feeder Calf Show Feedout project averaged 608 pounds upon delivery to the Carrington Research Extension Center Livestock Unit on Oct. 15, 2005. After an average 202-day feeding period, cattle averaged 1,249 pounds (at plant, shrunk weight). No deaths occurred during the feeding period. The early sell group (83 head) averaged 1,274 pounds (shrunk) at harvest. The second sell group (84 head) averaged 1,225 pounds. (shrunk) at harvest. Average daily feed intake per head was 28.3 pounds on an as fed basis and 20.6 pounds on a dry matter basis. Pounds of feed required per pound of gain were 8.90 on an as fed basis and 6.48 pounds on a dry matter basis.

Overall feed cost per pound of gain was $0.280. Overall yardage cost per pound of gain was $0.078. Combined cost per pound of gain, including feed, yardage, veterinary services, trucking and other expenses except interest, was $0.462.

The number of cattle consigned was 167, of which 129 competed in the pen-of-three contest. Cattle were not implanted during the feeding period.

The carcass characteristics were collected and used in calculating indexes for scoring. The first market group, harvested April 25, 2006, contained USDA Quality Grades at 1.2 percent Prime, 50.6 percent Choice or better (including 1.2 percent Certified Angus Beef), 43.4 percent Select and 4.8 percent Standard, and USDA Yield Grades at 12 percent YG1, 34.9 percent YG2, 36.6 percent YG3 and 14.5 percent YG4. The second market group, harvested May 16, 2006, contained USDA Quality Grades at 62.5 percent Choice (including 5.9 percent Certified Angus Beef), 34.5 percent Select and 3 percent Standard, and USDA Yield Grades at 2.4 percent YG1, 22.6 percent YG2, 59.5 percent YG3, 14.3 percent YG4 and 1.2 percent YG5.

Carcass value per hundredweight (cwt) was calculated by using the actual base carcass price plus premiums and discounts (Table 1).

Retail product value was calculated as carcass weight, pound * percent retail product *(((carcass value per cwt /100)/ retail product yield) / retail product markup) where retail product yield = 0.65, and retail product markup = 0.75. Percent retail product value was calculated as 0.825 - (calculated yield grade *0.05).

Results from the calves selected for the pen-of-three competition are listed in Table 2. Overall, the pen-of-three calves averaged 388 days of age and 1,255 pounds per head at harvest. Overall pen-of-three average daily gain was 3.2 pounds, while weight per day of age was 3.16 pounds. Overall pen-of-three marbling score was 435.1, or 35.1 percent, into the low Choice/small marbling category. (A marbling score of 400 equals Choice 0.) Retail product value averaged $1,357.16 per head. Retail product value divided by day of age averaged $3.48.

The highest combined index score per pen-of-three was 3.92. While the highest overall scoring pen did not place first in marbling score, the pen was first in harvest weight, average daily gain, weight per day of age, percent retail product value divided by weight per day of age, and profit. The correlation between the index score total and profit was fair (r = 0.7807). Correlations between profit and average daily gain, weight per day of age, marbling score or percent retail product value divided by weight per day of age are shown in Table 3.

Profit or loss was calculated using initial calf price as price per pound, $ = 175.3239 – (0.075966 * initial calf weight). Profit or loss accounted for initial calf price, feed, yardage, veterinary services, freight, brand inspection, beef check-off, ultrasound and carcass data collection costs. Interest costs on

Table 1. Premiums and discounts for carcasses.

Market date	April 25, 2006	May 16, 2006
Bases Price per Cwt. – Choice, Yield Grade 3	$133.03	$130.81
Premiums		
Prime	$26.80	$26.95
CAB (Certified Angus Beef)	$7.55	$6.91
Yield Grade 1	$6.50	$6.50
Yield Grade 2	$2.50	$2.50
Discounts		
Select	$13.20	$15.70
Standard	$15.50	$18.00
Yield Grade 4	$10.00	$10.00

Table 2. Feeding performance — 2005-2006 Dakota Feeder Calf Show Feedout

Pen	Best Three Score Total	Average Birth Date	Average Harvest Weight	Average Daily Gain	Average Weight per Day of Age	Marbling Score	Ave Retail Product Value/DA	Ave Feeding Profit or Loss/Head
1	3.492	28-Mar-05	1418	3.96	3.56	447	$4.05	$54.77
2	3.481	5-Apr-05	1264	2.96	3.29	630	$3.97	$(4.15)
3	3.291	7-May-05	1208	3.06	3.37	457	$4.02	$(54.53)
4	3.253	16-Apr-05	1271	3.48	3.23	507	$3.57	$(8.88)
5	3.224	23-Apr-05	1306	3.62	3.56	450	$3.46	$(101.81)
6	3.221	14-Apr-05	1262	3.42	3.24	507	$3.50	$(29.53)
7	3.211	7-Mar-05	1354	3.37	3.27	430	$3.80	$(28.21)
8	3.204	15-Mar-05	1303	3.36	3.21	473	$3.64	$(30.14)
9	3.202	11-Apr-05	1258	3.10	3.21	497	$3.68	$(29.32)
10	3.200	17-Apr-05	1257	3.42	3.19	523	$3.40	$(16.49)
11	3.162	16-Mar-05	1334	3.13	3.24	477	$3.62	$(54.56)
12	3.162	6-Mar-05	1354	3.40	3.27	417	$3.70	$(35.43)
13	3.157	29-Mar-05	1350	3.46	3.45	380	$3.69	$(83.23)
14	3.138	31-Mar-05	1233	3.14	3.17	380	$3.69	$(50.01)
15	3.137	23-Mar-05	1359	3.60	3.30	380	$3.64	$(38.81)
16	3.136	30-Apr-05	1281	3.52	3.43	440	$3.37	$(74.71)
17	3.131	6-Apr-05	1292	3.27	3.37	417	$3.62	$(109.30)
18	3.097	23-Mar-05	1333	3.29	3.36	333	$3.85	$(92.29)
19	3.095	11-Apr-05	1258	3.22	3.27	470	$3.39	$(90.02)
20	3.076	13-Mar-05	1215	3.16	2.88	510	$3.42	$(16.62)
21	3.074	3-Apr-05	1255	3.12	3.24	370	$3.79	$(76.87)
22	3.066	28-Mar-05	1239	3.15	3.10	500	$3.31	$(87.08)
23	3.044	2-Mar-05	1312	3.24	3.13	500	$3.19	$(73.04)
24	3.029	15-Apr-05	1204	3.05	3.04	460	$3.46	$(29.02)
25	3.017	7-Apr-05	1273	3.26	3.16	350	$3.51	$(81.08)
26	3.009	19-Mar-05	1247	3.23	3.00	453	$3.35	$(41.23)
27	2.999	23-Apr-05	1254	3.27	3.23	423	$3.29	$(70.83)
28	2.991	28-Mar-05	1283	3.24	3.26	350	$3.56	$(134.61)
29	2.990	3-Apr-05	1205	3.17	2.96	480	$3.25	$(48.65)
30	2.989	24-Mar-05	1135	2.68	2.82	553	$3.28	$(95.44)
31	2.985	24-Mar-05	1277	3.30	3.11	440	$3.24	$(103.05)
32	2.974	24-Apr-05	1217	3.08	3.15	417	$3.40	$(94.51)
33	2.920	21-Apr-05	1220	3.07	3.13	423	$3.23	$(79.56)
34	2.920	27-Mar-05	1190	2.88	3.03	360	$3.64	$(124.78)
35	2.914	24-Mar-05	1274	3.19	3.05	403	$3.28	$(74.60)
36	2.910	15-Mar-05	1253	2.99	3.09	343	$3.59	$(130.35)
37	2.884	31-Mar-05	1230	3.07	2.99	390	$3.34	$(95.61)
38	2.877	12-Apr-05	1215	3.21	3.07	323	$3.47	$(103.64)
39	2.845	5-May-05	1123	3.07	2.99	480	$3.23	$(83.11)
40	2.758	11-Apr-05	1205	2.98	3.02	443	$2.80	$(162.71)
41	2.742	9-Apr-05	1178	2.79	3.04	343	$3.25	$(186.42)
42	2.736	15-Apr-05	1091	3.02	2.76	393	$3.06	$(99.58)
43	2.730	29-Mar-05	1180	2.80	2.86	387	$3.13	$(137.71)
average	3.057	3-Apr-05	1,255.135	3.205	3.165	435.116	3.482	(72.250)
Standard Deviation	0.175	15.904	65.905	0.239	0.182	65.422	0.262	45.963
n	43	43	43	43	43	43	43	43

Table 3. Correlation between profit and various production measures.

	Correlation coefficient
Profit and Index Score	0.7807
Profit and Average Birth Date	-0.1076
Profit and Average Harvest Weight	0.4395
Profit and Average Daily Gain	0.5548
Profit and Weight Per Day of Age	0.3224
Profit and Marbling Score	0.5398
Profit and Percent Retail Product Value Divided by Day of Age	0.5268

cattle or feeding expenses 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 an $86.26 per head loss before interest was included. However, the top profit pen-of-three calves with superior genetics returned $54.77 per head, while bottom pen-of-three calves had a $186.42 per head loss.

Implications

Calf value is improved with superior carcass performance. Feedlot performance is also important for increased weight gain and heavier carcass weights. Exceptional average daily gains, weight per day of age, marbling score and retail product value can be found in North Dakota beef herds. Feedout projects provide a source of information for cattle producers to learn about genetics and discover cattle value.

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Factors influencing sale price of North Dakota calves

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Data were collected from three auction markets in North Dakota in late autumn and in midwinter to determine the destination and factors influencing sale price of feeder calves from these auction markets. Marketing calves in larger lot sizes and with vaccinations, announced by the auctioneer, receive premiums, compared with calves sold in smaller lot sizes or with no vaccination history. The most frequent state destinations for North Dakota feeder cattle, in order based on number of cattle received, were North Dakota, South Dakota and Nebraska.

Introduction

Calves in value-added calf programs sell at higher prices, compared with unweaned, unvaccinated calves (King et al., 1996; King and Seeger, 2004; Corah et al., 2006). The price advantage for calves in value-added calf programs has been increasing in recent years (King and Seeger, 2004). Additional factors influencing sale price in these studies were region of the country, sex, breed description, horns, weight variation, lot size, flesh and frame score.

Little quantitative information exists on factors influencing price of North Dakota calves. Furthermore, the destination of calves sold in North Dakota auction markets have not been described, and the effect of destination on sale price also has not been measured.

The objectives of this study were to determine the first destination of calves from North Dakota auction markets and factors influencing sale price of calves.

Methods

Data were collected from three auction markets: Napoleon Livestock, Napoleon; Kist Livestock, Mandan; and Stockmen's Livestock, Dickinson, during three consecutive weeks in late October and November 2005, when most calves sold were freshly weaned. Data again were collected from the same auction markets for three consecutive weeks in January 2006. North Dakota State University representatives were present at the sales and collected the following information for each lot of calves sold: 1) lot number, 2) lot size, 3) sex, 4) weight, 5) hair color, and 6) vaccinations and deworming products. ZIP codes of destinations of calves were determined from market clearance records from each auction market.

Results

Destinations of feeder calves sold during late autumn (October and November) 2005 are shown in Figure 1. Data collected on 31,312 feeder calves sold in the fall indicated they were shipped to 11 states, including various locations in North Dakota. The majority of these feeder calves remained in North Dakota (46 percent). South Dakota destinations accounted for 18 percent of the cattle, while Nebraska destinations accounted for 14 percent of the total. Iowa and Minnesota rounded out the top five with 8 percent and 5 percent, respectively. The remainder of the feeder calves was shipped to Illinois, Oklahoma, Kansas, Colorado, Wyoming and Montana.

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[3]Stark County Extension office, Dickinson

[4]Logan County Extension office, Napoleon

[5]Kidder County Extension office, Steele

Figure 2 indicates the destination of cattle sold during midwinter (January) 2006. A total of 29,907 feeder calves were included in the data set during this time. North Dakota destinations accounted for a majority of the cattle sold, with 41 percent of the total. South Dakota accounted for 15 percent of the total, while Nebraska and Kansas were destinations for 12 percent and 10 percent, respectively. In January, 7 percent of North Dakota feeder calves were shipped to Colorado, while 6 percent were shipped to Montana. Kansas and Colorado received heavier, weaned calves, while the majority of calves shipped to Montana were replacement heifers.

Factors influencing price of calves sold in late autumn (October, November) 2005 are shown in Table 1. Calves sold during this period averaged 537 pounds.

Lot size effected ($P < 0.001$) calf price. Calves sold in large lot sizes (≥ 21 calves) received greater premiums ($P = 0.05$) than lot sizes of six to 10 and 11 to 20. Calves sold in lot sizes of 11 to 20 and six to 10 were priced similarly ($P = 0.45$) and sold for $128.92/hundredweight (cwt) and $128.59/cwt, respectively. Calves sold in lot sizes of ≤ five sold for less than the other lot sizes ($123.95/cwt).

As expected, calf sex influenced ($P < 0.001$) sale price. Steer calves sold for $7.98/cwt more ($P < 0.001$) than heifer calves. Steers sold for $131.84/cwt, while heifers sold for $123.86/cwt.

An effect ($P < 0.001$) of color was observed. Black cattle sold for $0.90/cwt more than ($P = 0.04$) white cattle. White cattle sold for $128.37/cwt, which was greater ($P = 0.05$) than the price received for red cattle ($127.31). Despite this, red cattle received a premium ($P = 0.05$) of $0.88/cwt when compared with pens of mixed-color cattle.

An effect ($P < 0.001$) of vaccinations was observed for calves sold in the fall. Calves vaccinated with a seven-way clostridial plus four-way viral plus *Pasteurella* vaccine (commonly referred to as the 741 vaccination program) sold for $128.68/cwt, which was greater ($P = 0.03$) than calves receiving only a four-way viral vaccination. Calves receiving only a four-way viral vaccination received $0.80/cwt more ($P = 0.03$; $127.83) than calves with no vaccination history or receiving only a seven-way clostridial vaccination ($127.03).

Due to limited numbers of calves that received implants during late autumn, data could not be analyzed statistically.

Factors influencing price of calves sold in midwinter (January) 2006 are shown in Table 2. Calves sold during this period had an average weight of 627 pounds.

Lot size had an effect ($P < 0.001$) on calf price. No differences ($P \geq 0.13$) were observed for lot sizes of ≥ 21,

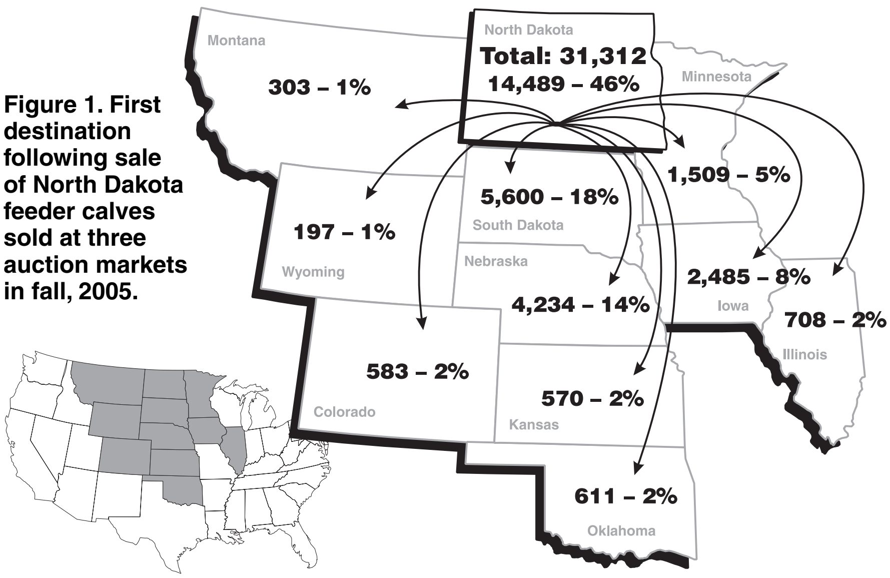

Figure 1. First destination following sale of North Dakota feeder calves sold at three auction markets in fall, 2005.

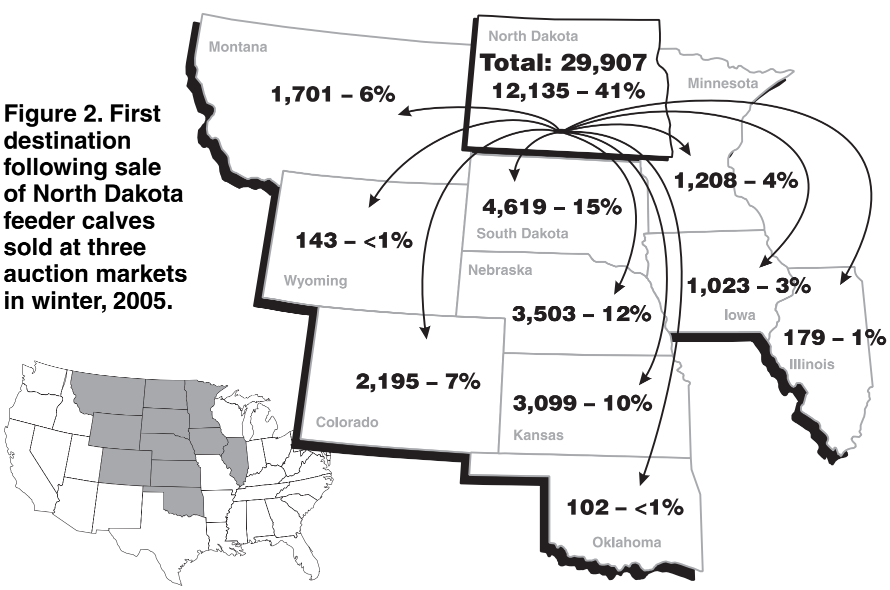

Figure 2. First destination following sale of North Dakota feeder calves sold at three auction markets in winter, 2005.

11 to 20 or six to 10, which sold for $122.13, $122.94 and $122.32/cwt, respectively. Calves sold in lots sizes of ≤ five received lower ($P < 0.0001$; $119.75/cwt) prices, compared with the other lot sizes.

Calf sex had an effect ($P < 0.001$) on price. Steer calves sold for $123.16/cwt, while heifer calves sold for $120.42/cwt. Thus, steers received $2.74/cwt more than heifers. The low price spread is due to more replacement heifers being sold.

Color influenced ($P = 0.003$) calf sale price. No differences ($P = 0.97$) were observed between black and white cattle ($122.36/cwt and $122.34/cwt, respectively). Mixed-color and red cattle received similar ($P = 0.74$; $121.29/cwt and $121.15/cwt, respectively) prices when compared with each other. However, black and white cattle received more ($P \leq 0.01$) per hundredweight when compared with mixed-color and red cattle.

An effect ($P = 0.05$) of vaccinations was observed. Calves sold with a four-way viral or 741 vaccination program were similarly priced ($P = 0.73$; $122.02/cwt and $121.91/cwt, respectively). Calves without a vaccination history or only a seven-way clostridial vaccination sold for $121.43/cwt. Calves with a 741 vaccination program tended ($P = 0.06$) to receive a greater price when compared with nonvaccinated calves.

Implant status had an effect ($P < 0.001$) on sale price of calves sold in midwinter. Calves without an implant sold for $122.55/cwt, compared with calves that received an implant, which sold for $121.02/cwt.

Table 1. Factors influencing price of North Dakota calves during late autumn 2005.

Factor	Number of lots	Lot price[1]	Price premium over baseline[1]	*P*-value
Lot size				<0.001
≥ 21	355	129.93[a]	5.98	
11–20	548	128.92[b]	4.97	
6–10	677	128.59[b]	4.64	
≤ 5	2033	123.95[c]	0.00	
Calf sex				<0.001
Steers	1977	131.84[a]	7.98	
Heifers	1636	123.86[b]	0.00	
Color				<0.001
Black, BWF[2]	1993	129.28[a]	2.84	
White	341	128.37[b]	1.94	
Red, RWF[3]	482	127.31[c]	0.88	
Mixed	797	126.43[d]	0.00	
Vaccinations				<0.001
741[4]	1222	128.68[a]	1.65	
4-way viral	580	127.83[b]	0.80	
No vaccinations[5]	1811	127.03[c]	0.00	
Base weight[6]	3613		-10.20	
Base weight (quadratic)	3613		0.01	

[1]$/hundred pounds.
[2]BWF = black white face.
[3]RWF = red white face.
[4]7-4-1 = 7-way clostridial plus 4-way viral plus *Pasteurella.*
[5]No vaccination history, but may have 7-way clostridial.
[6]Mean base weight of all lots (537 lb.) minus base weight of each lot; indicates price slide for increased selling weight.
[abcd]Within a column, means for specific factors without a common superscript letter differ (P ≤ 0.05).

Conclusions

North Dakota ZIP codes were the most frequent destinations during late autumn. Calves sold in larger lot sizes received premiums when compared with smaller lot sizes. As expected, calf sex and color had an effect on the price producers received. Vaccinated calves sold for more than calves without a vaccination history.

During midwinter, calves were shipped to 11 states, with the majority remaining in North Dakota. Calves sold in lot sizes of ≥ six were priced similarly, but received a premium, compared with small lot sizes. Black and white calves were similar in price but did receive premiums when compared with mixed-color and red calves. Calves that received a viral vaccination sold for more than calves with no vaccination history and calves not receiving an implant received higher prices than those calves that were implanted.

Implications

These data suggest that the price received is dependent on multiple factors. Selling vaccinated calves in larger lot sizes seems to be economically advantageous.

Table 2. Factors influencing price of North Dakota calves during midwinter 2006.

Factor	Number of lots	Lot price[1]	Price premium over baseline[1]	*P*-value
Lot size				<0.001
11–20	496	122.94[a]	3.20	
6–10	597	122.32[a]	2.57	
$\geq$ 21	392	122.13[a]	2.38	
$\leq$ 5	2027	119.75[b]	0.00	
Calf sex				<0.001
Steers	1878	123.16[a]	2.74	
Heifers	1636	120.42[b]	0.00	
Color				<0.001
Black, BWF[2]	1699	122.36[a]	1.21	
White	331	122.34[a]	1.19	
Mixed	789	121.29[b]	0.14	
Red, RWF[3]	696	121.15[b]	0.00	
Vaccinations				0.05
4-way viral	849	122.02[a]	0.60	
741[4]	1160	121.91[ab]	0.49	
No vaccinations[5]	1506	121.43[b]	0.00	
Implants				<0.001
No	2912	122.55[a]	1.52	
Yes	603	121.02[b]	0.00	
Base weight[6]	3514		-10.10	<0.001
Base weight (quadractic)	3514		0.01	<0.001

[1]$/hundred pounds.
[2]BWF = black white face.
[3]RWF = red white face.
[4]741 = 7-way clostridial plus 4-way viral plus *Pasteurella*.
[5]No vaccination history, but may have 7-way clostridial.
[6]Mean base weight of all lots (627 lb.) minus base weight of each lot; indicates price slide for increased selling weights.
[ab]Within a column, means for a specific factor without a common superscript letter differ (P < 0.05).

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