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2018 North Dakota Beef and Sheep Report

NDSU NORTH DAKOTA STATE UNIVERSITY

(Photo by Carl Dahlen, NDSU)

2018 North Dakota Beef and Sheep Report

This is the seventh year that I have been the coordinator and editor of the North Dakota Beef Report, and I still very much enjoy this activity because it is an important means to report our research findings to producers and industry personnel across North Dakota and beyond.

Our goal is to make this a comprehensive report describing research from across the state so readers have one report that provides results they can use to improve their operations or businesses.

For the first time, we are including sheep research reports, which should make the report even more comprehensive, providing research results that could be useful to beef cattle and sheep producers and industry personnel. Therefore, we are changing the name this year to the North Dakota Beef and Sheep Report.

The beef and sheep research programs at the North Dakota Agricultural Experiment Station's Main Station in Fargo and the Research Extension Centers across North Dakota are dedicated to serving the producers and stakeholders in North Dakota by developing new knowledge and technology to improve the management, efficiency and production of high-quality cattle, beef, sheep and lamb.

This report includes a broad range of research from on-campus departments, schools and centers, as well as the Research Extension Centers, and provides producers and stakeholders with one document that contains reports of beef- and sheep-related research conducted at NDSU during the year.

I again thank Ellen Crawford and Deb Tanner for their great assistance in editing and formatting the reports so that we can publish a great statewide combined report. Also, thanks to the contributors to the report, and to the staff and students who help with the research, teaching and Extension activities related to beef cattle and sheep.

Finally, thanks to the funders of the grants that help fund the research projects and students/staff working on the projects. We truly appreciate your contributions to our research program; without this support, the research would not be possible.

If you have any questions about the research reported in this report, please do not hesitate to contact me or any of the authors of the individual reports. Thanks for your encouragement and support of beef cattle and sheep research in North Dakota.

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The relationship between creep feeder appearance preweaning and calf intake, gain and feed efficiency post-weaning

Kacie McCarthy[1], Leonardo Sitorski[1], Kendall Swanson[1], Sarah Underdahl[1], Trent Gilbery[1], Kevin Sedivec[2], Bryan Neville[3] and Carl Dahlen[1]

The objectives of this study were to determine the effect of preweaning creep feeding behavior on postweaning feeding behavior, performance and carcass characteristics. Steer attendance at creep feeders was categorized as FREQUENT (attending greater than 80 percent of days) or INFREQUENT (attending less than 80 percent of days). Steers that attended the creep feeders more frequently ate more meals and spent more time eating during the first 28 days of the finishing period, compared with infrequent steers.

Summary

Suckling crossbred Angus steers (n = 24) at the Central Grasslands Research Extension Center (Streeter, N.D.) were fitted with transmission beacons on collars to determine the effect of preweaning creep feeding behavior on postweaning feeding behavior, performance and carcass characteristics. Preweaning data included the number of days the steers visited creep feeders and total minutes at the feeder. Calves then were weaned and acclimated to finishing diets and the Insentec feeding system (which recorded feed intake and behavior) during a 24-day transition period, followed by a 172-day finishing period. Steer attendance at creep feeders was categorized as FREQUENT (attending greater than 80 percent of days) or INFREQUENT (attending less than 80 percent of days). During the 24-day transition period, frequent creep feeder visitors ate more meals (P = 0.05) but had reduced time per meal, intake per meal and dry-matter intake (DMI) ($P \leq 0.03$), compared with infrequent visitors. During the first 28 days of finishing, frequent creep feeder visitors spent more time eating and ate more meals, compared with infrequent visitors ($P \leq 0.01$), but infrequent visitors ate more DMI per meal and ate faster ($P \leq 0.04$). The frequency of creep feeder attendance had no impact on DMI, average daily gain (ADG) or gain-to-feed ratio (G:F) during the feeding period, or on carcass weight, marbling or longissimus muscle area ($P \geq 0.19$). Overall, data indicate that preweaning creep feeder attendance influenced postweaning feeding behavior and carcass characteristics.

Introduction

Nursing calves have been given supplements to increase preweaning weight gains (Tarr et al., 1994; Loy et al., 2002), reduce grazing pressure and improve intake at weaning (Reed et al., 2006). Increased weaning weights of calves can increase the gross income of many cow-calf production systems that sell calves at weaning (Martin et al., 1981; Tarr et al., 1994).

Additionally, creep feeding has been found to alter behavior by training calves to recognize milled feed and availability of feed from mechanical devices (Pritchard, 2013). Utilization of such devices can help producers understand feeding behavior and monitor calf performance in grazing settings.

Electronic ID systems have been used largely to qualify calves for export programs and, to a lesser extent, manage calves in feedlot scenarios. However, systems that integrate electronic identification on a ranch level into future decisions about cattle management are not available. Development of such systems could result in many improvements in management of cattle and management or feeding approaches to improve the efficiency of production of calves and beef.

The use of electronic monitoring systems in the beef industry has been limited; these systems primarily have been used in research settings to examine the effects on feed intake in relation to cattle growth performance (Islas et al., 2014), health status (Wolfger et al., 2015) or animal movement in extensive pasture settings (Schauer et al., 2005). These technologies could be adapted easily for use in beef cattle production systems to monitor activity, feeding or drinking behavior, or as tools for monitoring inventories in intensive or extensive production systems.

Tremendous potential exists for utilizing these types of technologies to predict cattle performance that will allow for the development of

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[3]Carrington Research Extension Center, NDSU

precision management programs. Therefore, the objectives of this study were to evaluate the effect of preweaning creep feeding behavior on postweaning feeding behavior, performance and carcass characteristics.

Experimental Procedures

All procedures were conducted in accordance with the North Dakota State University Institutional Animal Care and Use Committee.

Animal Procedures

Suckling crossbred Angus steers (n = 24) at the Central Grasslands Research Extension Center (Streeter, N.D.) were fitted with transmission beacons equipped with radio-frequency identification and accelerometers (Remote Insights Inc., Minneapolis, Minn.) on collars. Each beacon contained an accelerometer, and upon movement, transmitted data to receiver gateways placed at the feeders.

All calves had access to creep feeders equipped with beacon gateways that sent data through a cellular network to a cloud platform. Preweaning data included number of days visiting creep feeders and total minutes at the feeder. Data from 32 working beacons were recorded for the creep feeding period (24 days) prior to the calves being shipped to the Beef Cattle Research Complex (BCRC) in Fargo, N.D.

At weaning, weights were recorded and calves were shipped to the BCRC. Steers were acclimated to finishing diets and an Insentec feeding system (Hokofarm Group B.V., the Netherlands), which recorded feed intake and behavior during a 24-day transition period, followed by a 172-day finishing period.

On completion of the trial, data from the Insentec feed system were combined with the creep feeder beacon data. Feed intake and behavior were summarized by day for each individual steer.

Steer attendance at creep feeders was categorized as FREQUENT (n = 13; attending greater than 80 percent of days) or INFREQUENT (n = 11; attending less than 80 percent of days). Postweaning feeding behavior data were summarized by 1) ration transition period (24 days) and 2) first 28 days on the finishing ration.

Carcass characteristics were collected at slaughter at a commercial abattoir. Hot carcass weight data were obtained following animal slaughter, whereas marbling score; back fat; longissimus muscle area; kidney, pelvic and heart fat (KPH); and yield grade were taken after carcasses were chilled in the cooler.

Analysis

All data were analyzed for the effects of creep feeder attendance on postweaning feeding behavior, and carcass characteristics were analyzed using the GLM procedure of SAS (9.4; SAS Institute Inc., Cary, N.C.). Differences were considered significant at $P < 0.05$.

Results and Discussion

During October, beacons were recording the appearance or number of visits per calf at the creep feeders (Figure 1). Overall, the feeders were visited at least five minutes per day throughout the month. The maximum amount of time spent at the creep feeder was 28 minutes in one day.

Data for feeding behavior are reported in Tables 1 and 2. Steers in the frequent category attended feeders an average of 90.6 percent of days, whereas steers in the infrequent category attended feeders an average of 62.5 percent of days.

During the 24-day transition period (Table 1), frequent creep feeder visitors ate more meals ($P = 0.05$) but had reduced time per meal, intake per meal and DMI ($P \leq 0.03$), compared with infrequent visitors. Steers that attended the creep feeder more frequently attended the feedlot bunks within the first seven days upon arrival to the BCRC a greater percentage of time, compared with infrequent visitors (59 vs. 37 percent, respectively).

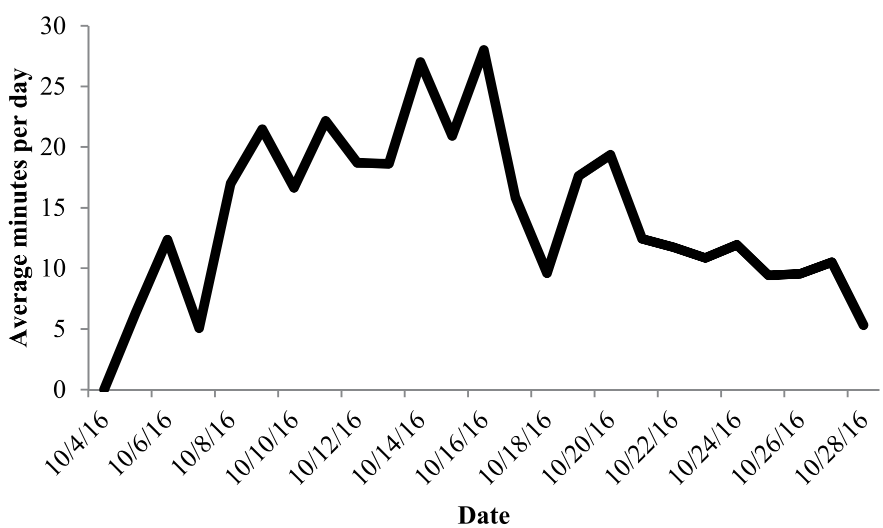

Figure 1. Average minutes per day suckling crossbred Angus steers (n = 24) fitted with transmission beacons on collars visited creep feeders during a 24-day creep feeding period.

During the first 28 days of finishing (Table 2), frequent creep feeder visitors spent more time eating and ate more meals, compared with infrequent visitors ($P \leq 0.01$), but infrequent visitors ate more DMI per meal and ate faster ($P \leq 0.04$).

Frequency of creep feeder attendance had no influence on DMI, ADG or G:F during the feeding period, or on carcass weight, marbling or longissimus muscle area ($P \geq 0.19$). Studies of creep feeding calves for 28 days showed no advantage in feedlot performance and carcass characteristics, compared with longer time on creep feed (Tarr, 1994).

Back fat and yield grade were greater for frequent visitors ($P \geq 0.03$), compared with infrequent visitors (Table 3). Studies of calves gaining similarly to the calves in this study have shown mixed results regarding back fat thickness, with increased time on creep feed resulting in greater fat thickness (Tarr, 1994).

Overall, data indicate that preweaning creep feeder attendance influenced postweaning feeding behavior and carcass characteristics. Steers in this study that frequently attended a creep feeder attended the feedlot bunks a greater percentage of time upon feedlot arrival. Additionally, greater responses to back fat and yield grade were found in steers that frequently attended creep feeders, with a tendency for the percent of KPH to be greater in those steers attending creep feeders frequently.

These data support behavioral changes found when training calves to recognize milled feed from mechanical devices (Pritchard, 2013). Utilization of such devices, as reported here, can help producers understand feeding behavior and monitor calf performance in grazing settings. With changes in feeding behavior prior to entry into the feedlot, producers who choose to retain calves through finishing have opportunities to improve carcass characteristics with preweaning creep feeding attendance as reported here.

Table 1. Influence of frequency of creep feeder visits on transition period feeding behavior of crossbred Angus steers.

	Visiting Frequency Category[1]			
Item	Frequent	Infrequent	SE	*P*-Value
No. of steers	13	11		
Number of days eating (7 days)	4.15	2.6	0.45	0.02
Number of days eating (24 days)	21.2	19.5	0.47	0.02
% Attendance 7 days	0.59	0.37	0.06	0.02
% Attendance 24 days	0.88	0.81	0.02	0.26
Training (24 days)				
DMI, lbs.	11.66	13.56	0.57	0.03
Time spent eating, min.	93.12	102.08	6.98	0.37
Visit	39.3	33.4	3.07	0.20
Meal	13.97	12.43	0.52	0.04
Time per visit, min.	2.34	3.47	0.29	0.01
Time per meal, min.	6.55	8.33	0.54	0.02
Lbs. per visit	0.297	0.474	0.046	0.01
Lb. per meal	0.818	1.117	0.053	0.01
Lb. per min.	12.46	7.19	3.48	0.29

[1]Steers in the Frequent category attended feeders an average of 90.6 percent of days, whereas steers in the Infrequent category attended feeders an average of 62.5 percent of days.

Table 2. Influence of frequency of creep feeder visits on growth performance and feeding behavior in crossbred Angus steers during the first 28 days on a finishing ration.

	Visiting Frequency Category[1]			
Item	Frequent	Infrequent	SE	*P*-Value
No. of steers	13	11		
DMI[2], lbs.	14.13	14.49	0.66	0.77
ADG[3], lbs.	2.18	1.98	0.33	0.66
G:F	0.153	0.130	0.149	0.45
Time spent eating, min.	158.4	126.4	7.91	0.01
Visits	33.8	27.2	3.17	0.15
Meals	12.7	10.7	0.52	0.01
Time per visit, min.	5.86	6.83	0.80	0.41
Time per meal, min.	13.31	12.61	1.03	0.64
Lb. per visit	0.547	0.818	0.082	0.03
Lb. per meal	1.878	2.322	0.141	0.04
Lb. per min.	0.146	0.189	0.006	<0.001

[1]Steers in the Frequent category attended feeders an average of 90.6 percent of days, whereas steers in the Infrequent category attended feeders an average of 62.5 percent of days.
[2]DMI = dry mater intake.
[3]ADG = average daily gain.

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Table 3. Impact of frequency of creep feeder visits on carcass characteristics of crossbred Angus steers.

	Visiting Frequency Category[1]			
Item	**Frequent**	**Infrequent**	**SE**	***P*-Value**
No. of steers	13	11		
HCW[2], lbs.	809.5	785.9	18.9	0.39
Marbling score[3]	487.4	445.3	21.7	0.19
Back fat, cm	1.40	1.02	0.09	0.01
Longissimus muscle area, cm^2	84.13	84.83	1.93	0.80
KPH, %	2.02	1.88	0.052	0.07
Calculated yield grade	3.24	2.66	0.176	0.03

[1]Steers in the Frequent category attended feeders an average of 90.6 percent of days, whereas steers in the Infrequent category attended feeders an average of 62.5 percent of days.

[2]HCW = hot carcass weight.

[3]Marbing score: 300 = traces, 400 = slight, 500 = small, 600 = modest, 700 = moderate, 800 = slightly abundant.

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Discovering value in North Dakota calves: Dakota Feeder Calf Show feedout project XVI, 2017-2018

Karl Hoppe[1] and Dakota Feeder Calf Show Livestock Committee[2]

The Dakota Feeder Calf Show feedout project assists cattle producers in identifying cattle with superior growth and carcass characteristics. The spread in average profitability between consignments from the top five herds and the bottom five herds was $170.16 per head for the 2017-2018 feeding period.

Summary

The Dakota Feeder Calf Show feedout project was developed to discover the actual value of spring-born beef steer calves, provide comparisons among herds, and benchmark feeding and carcass performance. Cattle consigned to the feedout project were delivered to the Carrington Research Extension Center Livestock Unit on Oct. 17, 2017. After a 207-day feeding period with 2.11 percent death loss, cattle averaged 1,311.1 pounds (shrunk harvest weight). Feed required per pound of gain was 6.74 (dry-matter basis). Overall pen average daily gain was 3.14 pounds. Feed cost per pound of gain was $0.474 and total cost per pound of gain was $0.748. Profit ranged from $227.75 per head for pen-of-three cattle with superior growth and carcass traits to minus $15.02 per head (no death loss). Substantial variability in the feeding and carcass value of spring-born calves continues to be discovered through participation in the feedout project.

Introduction

Determining calf value is a learning 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 and management. Marketplace premiums are provided for calves that have exceptional feedlot performance and produce a high-quality carcass.

In addition, cost-effective feeding performance is needed to justify the expense of feeding cattle past weaning. Because North Dakota has low-cost feeds and a favorable climate, low cost per pound of gain can be accomplished (Hoppe et al., 1997).

Combining the low cost of gains with the identification of superior cattle, this ongoing feedlot project provides cattle producers with an understanding of cattle feeding and cattle selection in North Dakota.

Experimental Procedures

The Dakota Feeder Calf Show was developed for cattle producers willing to consign steer calves to a show and feedout project. The calves were received in groups of three or four on Oct.17, 2017, at the Turtle Lake Weighing Station, Turtle Lake, N.D., for weighing, tagging, veterinary processing and showing. The calves were evaluated for conformation and uniformity, with the judges providing a discussion to the owners at the beginning of the feedout. The number of cattle consigned was 142, of which 120 competed in the pen-of-three contest.

The calves then were shipped to the Carrington Research Extension Center, Carrington, N.D., for feeding. Prior to shipment, calves were vaccinated, implanted with Synovex-S, dewormed and injected with a prophylactic long-acting antibiotic.

Calves then were sorted and placed on corn-based receiving diets. After an eight-week backgrounding period, the calves were transitioned to a 0.62 megacalorie of net energy for gain (Mcal NEg) per pound finishing diet. Cattle were weighed every 28 days, and updated performance reports were provided to the owners. Cattle were reimplanted with Synovex-Choice.

An open house was held on Feb. 2, 2018, at the Carrington Research Extension Center Livestock Unit, where the owners reviewed the calves and discussed marketing conditions.

The cattle (139 head) were harvested on May 17, 2018. The cattle were sold to Tyson Fresh Meats, Dakota City, Neb., on a grid basis, with premiums and discounts based on carcass quality. Carcass data were collected after harvest.

Ranking in the pen-of-three competition was based on the best overall score. The overall score was determined by adding the index values for feedlot average daily gain (25 percent of score), marbling score

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[2]Turtle Lake, N.D.

(25 percent of score) and profit (25 percent of score) and subtracting the index value for calculated yield grade (25 percent of score). The Dakota Feeder Calf Show provided awards and recognition for the top-ranking pen of steers.

Results and Discussion

Cattle consigned to the Dakota Feeder Calf Show feedout project averaged 634.19 pounds upon delivery to the Carrington Research Extension Center Livestock Unit on Oct. 17, 2017. After an average 207-day feeding period, cattle averaged 1,311.1 pounds (at plant, shrunk weight). Death loss was 2.11 percent (three head) during the feeding period.

Average daily feed intake per head was 32 pounds on an as-fed basis and 21.1 pounds on a dry-matter basis. Pounds of feed required per pound of gain were 10.2 on an as-fed basis and 6.74 pounds on a dry-matter basis.

The overall feed cost per pound of gain was $0.474. The overall yardage cost per pound of gain was $0.111. The combined cost per pound of gain, including feed, yardage, veterinary, trucking and other expenses except interest, was $0.748.

Calves were priced by weight upon delivery to the feedlot. The pricing equation ($ per 100 pounds = (-0.069506177* initial calf weight, pounds) + 212.8378297) was determined by regression analysis on local livestock auction prices reported for the weeks before and after delivery.

Overall, the carcasses contained U.S. Department of Agriculture Quality Grades at 1.4 percent Prime, 79.8 percent Choice or better (including 17.9 percent Certified Angus Beef), 18.7 percent Select, 0 percent Standard and 0 percent other, and USDA Yield Grades at 4.3 percent YG1, 48.2 percent YG2, 38.1 percent YG3, 8.6 percent YG4 and 0.71 percent YG5.

Carcass value per 100 pounds (cwt) was calculated using the actual base carcass price plus premiums and discounts for each carcass. The grid price received for May 17, 2018, was $195.04 Choice YG3 base with premiums: Prime $20, CAB $6, YG1 $6.50 and YG2 $3, and discounts: Select minus $12, Standard (no roll) minus $15, YG4 minus $8, YG5 minus $20 and carcasses greater than 1,050 pounds minus $20.

Results from the calves selected for the pen-of-three competition are listed in Table 1.

Overall, the pen-of-three calves averaged 407 days of age and 1,328.11 pounds per head at harvest. The overall pen-of-three feedlot average daily gain was 3.33 pounds, while weight gain per day of age was 3.27 pounds. The overall pen-of-three marbling score was 484.6 (low choice, small marbling).

Correlations between profit and average birth date, harvest weight, average daily gain, weight per day of age or marbling score are shown in Table 2. The average harvest weight, average daily gain and marbling score had positive correlations to profitability.

The top-profit pen-of-three calves returned $227.75 per head, while the bottom pen-of-three calves returned minus $15.02 per head. The average of the five top-scoring pens of steers averaged $187.54 per head, while the average of the bottom five scoring pens of steers averaged $17.37 per head.

For the pen-of-three competition, average profit was $95.80 per head. The spread in profitability between the top and bottom five herds was $170.16 per head.

Implications

Calf value is improved with superior carcass and feedlot performance. Exceptional average daily gains, weight per day of age, harvest weight and marbling score can be found in North Dakota beef herds. Feedout projects provide a source of information for cattle producers to learn about feedlot performance and individual animal differences, and discover cattle value.

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Table 2. Correlation between profit and various production measures (pen-of-three).

	Correlation coefficient
Profit and average birth date	-0.1326
Profit and average harvest weight	0.6644
Profit and average daily gain	0.6211
Profit and weight per day of age	0.5556
Profit and marbling score	0.2700
Profit and yield grade	0.2910

Table 1. Feeding performance - 2017-2018 Dakota Feeder Calf Show Feedout

Pen of Three	Best Three Score Total	Average Weight Average Birth Date	Average per Day of Age, lbs	Average Harvest Weight, lbs.	Average Daily Gain, lbs.	Average Marbling Score[1]	Average Calculated Yield Grade	Feeding Profit or Loss/Head
1	2.004	8-Mar-17	3.652	1582.5	3.788	587.7	3.151	$168.46
2	1.973	1-Apr-17	3.547	1453.2	3.928	630.0	4.045	$209.07
3	1.945	12-Mar-17	3.120	1339.5	3.388	457.3	2.426	$195.77
4	1.933	21-Mar-17	3.318	1393.2	3.623	575.0	3.355	$185.29
5	1.866	9-Apr-17	3.441	1382.2	3.682	498.0	3.134	$179.11
Average top 5 herds	**1.944**	**22-Mar-17**	**3.416**	**1430.115**	**3.682**	**549.600**	**3.222**	**$187.54**
6	1.837	28-Mar-17	3.335	1380.6	3.529	451.3	2.693	$166.13
7	1.813	10-Apr-17	3.097	1240.1	3.310	611.0	2.752	$70.78
8	1.698	22-Apr-17	3.257	1265.4	3.319	527.3	3.080	$114.21
9	1.683	9-Apr-17	3.385	1358.5	3.495	486.7	3.396	$153.14
10	1.666	26-Mar-17	3.589	1489.4	3.459	444.7	3.837	$227.75
11	1.629	3-Apr-17	3.332	1356.9	3.383	456.3	3.001	$118.02
12	1.611	22-Apr-17	3.659	1423.2	3.655	477.3	3.526	$124.89
13	1.600	11-Apr-17	3.466	1385.3	3.319	404.3	2.585	$102.28
14	1.586	7-Apr-17	3.267	1317.5	3.369	458.7	2.542	$47.28
15	1.575	12-Mar-17	2.862	1229.1	2.951	439.3	2.115	$52.10
16	1.569	13-Apr-17	3.553	1413.7	3.689	414.7	2.970	$85.27
17	1.562	2-Apr-17	2.986	1221.2	3.114	470.3	2.777	$80.78
18	1.530	1-Apr-17	2.966	1214.9	3.051	498.0	2.912	$68.03
19	1.518	18-Apr-17	3.316	1303.3	3.357	551.0	3.271	$32.97
20	1.518	7-Apr-17	3.291	1326.9	3.004	449.3	3.431	$159.66
21	1.512	16-Apr-17	3.455	1361.6	3.414	442.3	2.819	$51.54
22	1.512	16-Apr-17	3.375	1330.1	3.382	420.0	2.970	$87.48
23	1.470	13-Apr-17	3.258	1295.4	3.480	436.0	3.100	$61.53
24	1.427	24-Apr-17	2.968	1148.6	2.940	515.7	3.251	$58.11
25	1.425	18-Apr-17	3.448	1353.7	3.086	525.7	3.659	$80.04
26	1.388	10-Mar-17	2.901	1254.3	3.024	450.7	2.797	$27.41
27	1.385	13-Apr-17	3.131	1244.9	2.978	477.7	3.337	$71.77
28	1.377	12-Apr-17	3.231	1289.1	3.184	481.0	2.999	$6.68
29	1.350	9-Mar-17	2.851	1233.8	3.046	425.7	2.753	$20.96
30	1.329	17-Apr-17	3.591	1410.6	3.755	566.3	4.806	$65.82
31	1.321	4-Mar-17	3.003	1315.9	2.967	414.7	2.614	$8.43
32	1.191	16-Apr-17	3.003	1184.9	2.842	462.7	3.122	$(15.02)
Average bottom 5 herds	**1.314**	**30-Mar-17**	**3.136**	**1286.9**	**3.159**	**470.1**	**3.259**	**$17.37**
Overall average — pens of three	**1.588**	**4-Apr-17**	**3.270**	**1328.1**	**3.328**	**484.6**	**3.101**	**95.80**
Standard deviation		15.0	0.2	93.2	0.3	59.6	0.5	64.5
number		32	32	32	32	32	32	32

[1]Marbling score 300-399 = select, 400-499 = low choice, 500-599 = average choice, 600-699 = high choice, 700-799 = low prime

Evaluation of the interaction of injectable trace mineral and vaccination protocol on feed intake, performance and immune response of weaned calves

Janna Kincheloe[1], James Gaspers[2], Gerald Stokka[2] and Christopher Schauer[1]

This experiment evaluated the effects of respiratory vaccine and injectable trace mineral (ITM) on calf performance, feed intake and immune response. Calves in this study had similar average daily gain, feed intake and feed efficiency regardless of treatment. The use of an injectable trace mineral did not influence immune response. Additionally, we found minimal differences in antibody response from vaccinated vs. unvaccinated calves.

Summary

Stress at weaning can compromise immune function and performance of calves. Proper vaccination and adequate mineral status are two factors that may influence the susceptibility of weaned calves to respiratory diseases. Sixty-four Angus calves from the NDSU Hettinger Research Extension Center were utilized for this study. Three weeks prior to weaning, calves were allocated randomly to treatment in a randomized complete block design with a 2 × 2 factorial treatment structure including administration or no administration of 1) a MULTIMIN90 injectable trace mineral or 2) a vaccine targeting viral respiratory diseases. Following preweaning treatments, calves were returned to dams and managed as a common group until weaning. Calves were assigned to pens, with four animals per pen and four pens per treatment. Calves were fed a forage-based backgrounding diet for 37 days and marketed at a local livestock auction. Weights and blood samples were collected at preweaning, weaning and the end of the feeding period. Serum was separated from blood samples and analyzed for bovine respiratory syncytial virus (BRSV) and bovine viral diarrhea virus type 2 (BVDV 2) antibody responses. No differences were observed for calf feed intake, average daily gain (ADG) or feed efficiency due to treatments ($P > 0.10$). Vaccinated calves had increased BVDV 2 titers, compared with nonvaccinated calves, with titers decreasing in nonvaccinated calves from the beginning to the end of the study ($P < 0.001$). BRSV titers were not significant based on vaccination or injectable trace mineral (ITM) treatment ($P > 0.30$). Injectable trace mineral treatment did not affect titer levels for BRSV or BVDV 2 ($P = 0.58$). Vaccination for respiratory diseases and injection of trace mineral had minimal influence on animal performance and immune response in this study.

Introduction

Respiratory diseases are some of the most common and costly issues in the beef industry in terms of morbidity, mortality and widespread impacts on production. Deficiencies of trace minerals such as selenium, copper, zinc, cobalt and iron have been shown to be a factor in reduced disease resistance (Spears, 1995).

With increasing pressure to reduce the use of antibiotics in animal agriculture, we see a need to develop alternative management strategies that can be used during times of stress, such as weaning when the immune system may be compromised. Injectable trace mineral sources have been suggested to be beneficial during a period of increased stress or metabolic need to allow for rapid increases in trace mineral status and liver storage of minerals.

Data evaluating the use of injectable trace minerals with or without standard vaccines in weaning protocols is lacking. The current experiment was designed to evaluate the influence of a MULTIMIN90 injectable trace mineral or a negative control with or without standard preweaning and weaning vaccinations for respiratory diseases on feed intake, performance and immune response of beef calves consuming a forage-based diet in an approximately 35-day postweaning period.

Experimental Procedures

Three weeks prior to weaning on day zero of the experiment, 64 Angus calves raised at the NDSU Hettinger Research Extension Center were assigned randomly to one of four treatment groups: 1) MULTIMIN90 injection and vaccination for respiratory diseases (Vac-90); 2) No MULTIMIN90 injection, only vaccination for respiratory diseases (Vac); 3) MULTIMIN90 injection without vaccination for respiratory diseases (NoVac-90); and 4) No MULTIMIN90 injection or vaccina-

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tion for respiratory diseases (Con). MULTIMIN90 is an an injectable chelated aqeuous source of supplemental zinc, manganese, selenium and copper.

All calves received an injection of Ultrabac 7/Somubac for the prevention of clostridial diseases and *H. somni*. Only calves assigned to Vac and Vac-90 treatments received an additional injection of Bovi-Shield Gold One Shot for prevention of BVDV types 1 and 2, BRSV, infectious bovine rhinotracheitis (IBR), parainfluenza virus type 3 (PI3) and *Mannheimia haemolytica*.

Calves assigned to Vac-90 and NoVac-90 treatments received one injection of MULTIMIN90 based on recommended product dosage guidelines of 1 milliliter (mL) per 100 pounds of body weight. All vaccines and MULTIMIN90 were injected in the neck.

Calves were weighed and blood samples were collected via jugular venipuncture to determine pretreatment mineral status. Calves were returned to their dams and no further treatments were applied prior to weaning.

At weaning (day 21 of the experiment), calf weights and blood samples again were collected via jugular venipuncture, and calves were assigned to pens for the postweaning feeding trial. Each previously described treatment had four pen replicates, with four calves per pen.

The initial diet was fed from days one to 22 and consisted of mixed grass hay, haylage, soybean hull pellets, barley and protein supplement. Due to calves excessively sorting the diet, a portion of the soybean hull pellets was replaced with oats on day 23 and fed through the remainder of the trial.

Both diets were formulated to achieve approximate gains of 1.5 to 2 pounds/head/day (Table 1). Feed intake by pen was monitored by NDSU personnel. Feed intake and calf weight changes were utilized to calculate feed efficiency and average daily gain (ADG) by pen.

Three calves received one-time individual treatments of oxytetracycline due to signs of respiratory illness on day 19 (n = 2; one head each from Vac-90 and Vac treatments) and day 21 (n = 1; one head from NoVac-90 treatment) of the study. Treated calves remained in pens. Oral chlortetracycline (CTC) was administered to all calves on the study for a five-day period starting on day 27 due to reduced feed intake, abnormal nasal discharge, coughing and general lethargy.

The postweaning feeding period was concluded on Nov. 9. Final calf weights and post-treatment blood samples were collected on this date. Calves were sold at a local livestock auction market the following week. Serum samples collected on day zero (preweaning) and day 58 (end of postweaning feeding period) were packaged on ice and shipped overnight to the Texas A&M Veterinary Medical Diagnostic Laboratory in Amarillo, Texas, for BRSV and BVDV 2 antibody titer analyses.

All data were analyzed using the mixed procedure of SAS (SAS Ins. Inc., Cary, N.C.). Variables analyzed included ADG, feed intake, feed efficiency, BRSV antibody titers and BVDV 2 antibody titers. Antibody titers were converted using the natural log to normalize data. Significance was determined with an alpha of $P \leq 0.05$.

Results and Discussion

Preweaning weights across treatments averaged 502 pounds ± 1.5, and weights at weaning averaged 554 pounds ± 3.7. We found no effect ($P > 0.20$) due to either treatment or their interaction on ADG from preweaning to the end of the feeding period (avg. 2.34 pounds/head/day ± 0.122). Additionally, we found no differences ($P > 0.10$) in feed intake (DM feed/head/day) or feed efficiency (DM feed/pound of gain) during the postweaning feeding period (avg. 12.97 pounds ±

Table 1. Ingredient and nutrient composition (dry-matter [DM] basis) of postweaning rations for calves receiving or not receiving injections of MULTIMIN®90 or standard respiratory vaccines.

Item	Diet 1 (days 1 to 22)	Diet 2 (days 23 to 35)
Diet composition (DM basis)		
Mixed grass hay, %	36.7	41.9
Soybean hull pellets, %	38.3	18.1
Haylage, %	5.4	6.3
Barley, %	15.5	18.2
Oats, %	—	15.8
Protein supplement, %	4.0	5.2
Nutrient composition (DM basis)		
Diet dry matter, %	84.4	83.9
Crude protein, %	11.7	11.9
ADF, %	35.0	27.4
NDF, %	52.2	43.9
TDN, %	59.3	65.2
NE_m, Mcal/lb	0.58	0.67
NE_g, Mcal/lb	0.31	0.40

0.599 and 5.86 ± 0.250, respectively).

Injectable trace mineral (ITM) treatment did not influence BVDV 2 or BRSV titer response ($P \geq 0.23$). The three-way interaction of vaccination treatment, ITM and day of sampling were not significant for BVDV 2 or BRSV titer response ($P \geq 0.16$). Vaccination treatment and day were significant for BVDV type 2 titers ($P < 0.001$; Figure 1). Bovine respiratory syncytial virus titer response was not different based on vaccination or ITM treatment ($P > 0.30$). The interaction of BRSV titers by day was significant ($P = 0.002$; Figure 2).

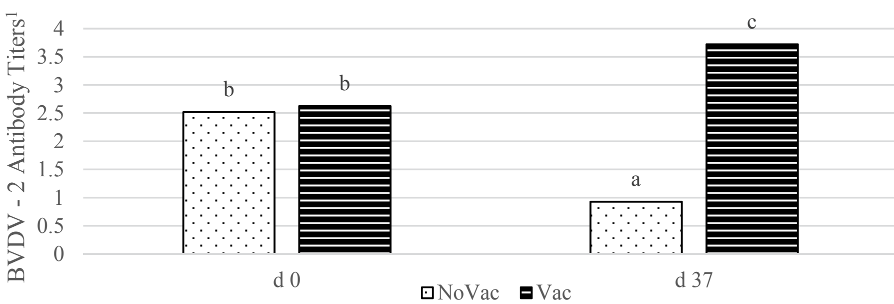
In the current study, none of the calves in the NoVac group responded with BRSV or BVDV 2 titer increases following injection. However, antibody responses observed for BVDV 2 and BRSV for calves assigned to the Vac groups were unexpected. Only 53 and 28 percent, respectively, of calves in the Vac group had any positive titer change to BVDV 2 and BRSV following vaccination.

All calves in this study received a multivalent modified live vaccine containing IBR, PI3, BRSV and BVDV types 1 and 2 at branding on June 6, 2017. A second preweaning dose was administered on Sept. 12, 2017. Three- to four-fold increases in antibody titer are considered to be indicative of a positive response to vaccination.

We anticipated that the majority of calves would have equal to or greater than a three-fold titer response to the vaccine based on vaccination history. We have several possible explanations for the lack of response.

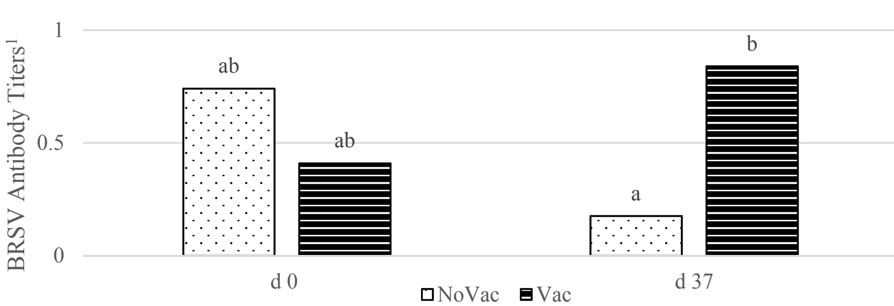
Modified live vaccines may be inactivated if mishandled and/or exposed to direct sunlight or temperature extremes during shipping, storage or vaccine administration. Additionally, temperature extremes could have affected serum samples submitted for antibody responses. Another possibility is that calves were highly stressed and experienced immunosuppression that prevented response to the administration of vaccine.

Trace minerals have an important role in optimizing the immune function of livestock, particularly during times of stress in feeder calves (Duff and Galyean, 2007). However, studies evaluating the response of injectable trace minerals (ITM) in feeder calves have produced variable responses. Additional research is warranted to help elucidate the timing of the trace mineral injection in relation to weaning in addition to helping define the relationship between trace mineral status and vaccine administration when evaluating health and performance responses.



[1]SN titer value were normalized using the Natural Log. P - value for treatment and treatment by day effects were less than 0.001. [a,b,c] Bars with different letters differ by $P < 0.05$.

Figure 1. Bovine viral diarrhea virus (BVDV) type 2 antibody titers by vaccination treatment across time.



[1]SN titer value were normalized using the Natural Log. P - value for treatment by day effects were less than 0.0015. [a,b,c] Bars with different letters differ by $P < 0.05$.

Figure 2. Bovine respiratory syncytial virus titers by vaccination treatment across time.

Acknowledgments

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Utilizing an electronic feeder to measure mineral intake, feeding behavior and growth performance of cow-calf pairs grazing native range

Kacie McCarthy[1], Michael Undi[2] and Carl Dahlen[1]

The objective of this study was to evaluate an electronic feeder to monitor individual animal mineral intake and feeding behavior, and their relationship with growth performance and concentrations of minerals in the liver. The results indicate that mineral intake by grazing cattle is variable and corroborated with concentrations in the liver.

Summary

Crossbred Angus cow-calf pairs (n = 28 pairs) at the Central Grasslands Research Extension Center (Streeter, N.D.) were used to evaluate an electronic feeder to monitor mineral intake and feeding behavior, and their relationship with growth performance and concentrations of mineral in liver. Mineral intake, number of visits, time of visits and duration at the feeder were recorded during a 95-day monitoring period while pairs were grazing native range. Liver biopsies were conducted on cows on the final day of monitoring and analyzed for mineral concentrations. Cows were categorized into HIGH (greater than 3 ounces/day [oz/d]) and LOW (less than 3 oz/d) mineral intake groups. Mineral intake was greater ($P < 0.01$) in cows (2.9 ± 0.3 oz/d) than in calves (1.6 ± 0.3 oz/d), but both classes of cattle attended the mineral feeders a similar ($P = 0.71$) proportion of the days during the experiment (overall mean of only 20 percent, or once every five days). Interestingly, the daily mineral feeding recommendation (4 oz.) was exceeded by calves on days they visited the feeders (7.8 ± 0.9 oz/d), and calves had reduced ($P < 0.01$) intake on feeding days, compared with cows (12.6 ± 0.9 oz.). Cows with HIGH mineral intake had greater ($P < 0.01$) concentrations of selenium (Se) (2.92 vs. 2.41 micrograms per gram [ug/g]), copper (Cu) (247.04 vs. 115.57 ug/g) and cobalt (Co) (0.506 vs. 0.266 ug/g), compared with LOW mineral intake cows, but liver concentrations of iron (Fe), zinc (Zn), molybdenum (Mo) and manganese (Mn) did not differ ($P \geq 0.22$). We were able to monitor mineral intake and feeding behavior successfully with the electronic feeder evaluated, and the divergence in mineral intake observed with the feeder was corroborated by concentrations of mineral in the liver.

Introduction

Diet alone often does not supply sufficient amounts of minerals; therefore, supplementation is necessary to optimize animal health and performance (NASEM 2016). For effective supplementation, animals must consume the target amount of mineral to ensure desired mineral intake.

Research clearly has documented that intakes of minerals are variable among animals, with some cattle overconsuming or underconsuming supplements (Greene, 2000). Mineral intakes will vary depending on the season, individual animal requirements, animal preference, availability of fresh minerals, mineral palatability, physical form of minerals, salt content of water, mineral delivery method, soil fertility, forage type, forage availability and animal social interactions (Bowman and Sowell, 1997; McDowell, 2003).

Measurement of individual animals' mineral supplement intake allows specific animal responses to be evaluated. Current supplementation practices do not allow measurement of individual animal mineral intake; as a result, mineral intake is measured on a group basis.

Furthermore, the use of electronic monitoring systems in the beef industry has been limited; those systems primarily have been used in research settings to examine the effects on feed intake in relation to cattle growth performance (Islas et al., 2014), health status (Wolfger et al., 2015) or animal movement in extensive pasture settings (Schauer et al., 2005). These technologies could be adapted easily for use in beef cattle production systems to monitor activity, feeding or drinking behavior, or as tools for monitoring inventories in intensive or extensive production systems.

Therefore, our objective was to evaluate an electronic feeder to monitor individual animal mineral intake and feeding behavior,

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and their relationship with growth performance and concentrations of mineral in liver.

Experimental Procedures

All animal procedures were conducted in accordance with the Institutional Animal Care and Use Committee at North Dakota State University.

Electronic Feeder Device

The SmartFeed system (C-Lock Inc., Rapid City, S.D.) was used to deliver mineral supplement and measure intake. It features a stainless steel feed bin suspended on two load cells, a radio frequency (RFID) tag reader and antenna, an adjustable framework to allow access to one animal at a time, and a data acquisition system that records RFID tags and feed bin weights at 1 hertz (Hz) (Reuter et al., 2017). Mineral was monitored visually and through the online portal where intake and monitoring of the device can be done remotely.

Animal Measurements

Crossbred Angus cow-calf pairs (n = 28) at the Central Grasslands Research Extension Center (Streeter, N.D.) were used to evaluate an electronic feeder to monitor mineral intake and feeding behavior, and their relationship with growth performance and concentrations of mineral in the liver. Initial two-day body weights and body condition scores were collected prior to cattle being released onto pasture.

Cow-calf pairs were weighed every 28 days during the course of the grazing season. Final two-day body weights and body condition scores were collected on pasture prior to weaning.

Cows and calves were fitted with RFID ear tags that allowed access to the SmartFeed system that contained mineral (Purina Wind and Rain Storm, Land O'Lakes Inc., Arden Hills, Minn.). Mineral intake, number of visits, time of visits and duration at the feeder were recorded during a 95-day monitoring period while pairs were grazing native range.

Samples of liver were collected on the final day of monitoring via biopsy from a subset of cows with the greatest and least attendance at the mineral feeder throughout the grazing period.

Biopsy samples were stored in vacuum tubes designed for trace mineral analysis and stored at minus 20 C until further analysis. Liver samples were sent to the Michigan State Diagnostic Laboratory and were evaluated for concentrations of minerals. Results were used to evaluate whether mineral feeder attendance was related to liver mineral content.

Analysis

Data were analyzed in SAS (SAS Inst. Inc., Cary, N.C.), with mineral intake and feeding behavior compared among cows and calves via PROC GLM with significance at $P < 0.05$. Correlations were determined among cow feeding behavior, calf intake and growth performance with PROC CORR. Comparisons of liver mineral concentrations between cows of HIGH (greater than 3 oz/d) and LOW (less than 3 oz/d) mineral intake were analyzed with PROC GLM.

Results and Discussion

Mineral intake was greater ($P < 0.01$) in cows (2.9 ± 0.3 oz/d) than in calves (1.6 ± 0.3 oz/d), but both classes of cattle attended the mineral feeders a similar ($P = 0.71$) proportion of the days during the experiment (overall mean of only 20 percent, or once every five days). Mineral intakes fell within the range of 2 to 4 oz/d per animal suggested by Greene (2000) as a target for free-choice mineral supplements.

Interestingly, the daily mineral feeding recommendation (4 oz.) was exceeded by calves on days they visited the feeders (7.8 ± 0.9 oz./d), and calves had less ($P < 0.01$) intake on feeding days, compared with cows (12.6 ± 0.9 oz.).

During the grazing period, calves gained 2.58 ± 0.04 pounds per day (lb/d), whereas cows lost 0.77 ± 0.04 lb/d, but cow mineral intake and feeding behavior were not correlated ($P \geq 0.12$) with calf intake, feeding behavior or ADG.

Comparatively, steers that had access to a GrowSafe system supplying mineral supplement and were grazing spring- and fall-season pastures (36 ± 2d), consumed 3.4 and 3 oz/d of mineral, respectively (Manzano et al., 2012). These steers consumed more mineral than the cows and calves in the current study, but overall still fell within the suggested target range.

Furthermore, greater intake by cows than calves may be due to social interactions of dominant animals that often consume large amounts of supplement and prevent other animals from consuming desired amounts (Bowman and Sowell, 1997). Additionally, intakes often can be associated as a percentage of body weight, which could explain the larger animals consuming more mineral as a percentage of their body weight, compared with the smaller calves.

With the proportion of days during the experiment that cattle were consuming mineral, location of the mineral feeder and grazing behavior may explain the variation in intake during the grazing period. Mineral feeders were located down the fence line in a corner of the pasture, away from the water source. However, further observations of cattle movements would need to be made to understand frequency of attendance at the mineral feeder.

Cows with HIGH mineral intake had greater ($P < 0.01$) concentrations of Se (2.92 vs. 2.41 ug/g), Cu (247.04 vs. 115.57 µg/g) and Co (0.506 vs. 0.266 µg/g), compared with LOW mineral intake cows, but liver concentrations of Fe, Zn, Mo and Mn did not differ ($P \geq 0.22$; Table 1). Selenium concentrations in the liver for HIGH cows were classified as high adequate (greater than 2.50 µg/g DM; Kincaid, 1999), and for LOW mineral intake cows, levels were classified as adequate (1.25 to 2.50 µg/g DM; Kincaid, 1999).

Liver Cu concentrations are defined as adequate at 125 to 600 µg/g DM by Kincaid (1999) or normal at greater than 100 µg/g DM by Radostits et al. (2007). HIGH and LOW cows would be considered adequate to normal for liver Cu concentrations.

Liver Co levels for HIGH and LOW cows were adequate (0.10 to 0.40 µg/g DM). As defined by Kincaid (1999), liver mineral concentrations for Fe, Zn, Mo and Mn were adequate for HIGH and LOW groups.

In conclusion, we were able to monitor mineral intake and feeding behavior with the electronic feeder evaluated, and the divergence in mineral intake observed with the feeder was corroborated by concentrations of mineral in the liver.

Table 1. Concentrations of mineral in liver of cows with divergent mineral intake[1] (i.e. high or low).

	Intake Category			
Item, µg/g	High	Low	SE	*P*-Value
Se	2.92^{x}	2.41^{y}	0.10	0.01
Fe	202.31	220.0	21.90	0.58
Cu	247.04^{x}	115.57^{y}	21.57	0.01
Zn	110.70	118.68	16.51	0.74
Mo	3.98	3.75	0.29	0.59
Mn	9.74	8.84	0.497	0.22
Co	0.506^{x}	0.266^{y}	0.045	0.01

^{x,y}Means within row lacking common superscript differ significantly.
[1]Divergent mineral intake classified cows as HIGH (greater than 3 oz/d) or LOW (less than 3 oz/d) mineral intake.

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Corn Silage Quality Program

Carl Dahlen[1] and Miranda Meehan[1]

The quality and quantity of corn silage available for feed after ensiling is highly related to management factors around the time of harvest, through fermentation and storage, and during the feedout process. Plant growing conditions, harvest moisture, relative maturity, hybrid type, silo covering, kernel processing and silo face management all influenced silage quality. Producers are encouraged to evaluate factors influencing quality and take steps to maximize return on their corn silage investment.

Summary

Extension agents from 29 counties collected samples from 171 operations. Samples were collected from five locations along the feeding face of the silo. For each sample, a data collection card was filled out. The card detailed variety type, relative maturity, and growing and harvesting conditions, as well as silage management and feeding intentions. Samples were analyzed for dry matter, ash, crude protein, neutral detergent fiber, acid detergent fiber and in vitro dry-matter digestibility. The total digestible nutrient concentration was calculated, and each sample was processed through a Penn State Particle Separator for particle size determination. Wide variations in planting and harvest dates and sample nutrient composition were present in samples collected. Most producers were planting silage-type corn (73.9 percent), compared with grain (13.4 percent) or dual-purpose varieties (12.7 percent). The dry-matter (DM) concentration of grain varieties (41.4 percent) was greater ($P < 0.01$) than it was for silage varieties (35.6 percent). Similarly, shorter-day varieties (relative maturity less than 90 days; 40.8 percent) had a greater DM concentration, compared with longer-day varieties (35.5 percent for 90 to 100 days and 35.2 percent for greater than100-day relative maturity). The crude protein (CP) concentration of silages was influenced by producer-defined growing conditions, with those fields growing in poor or marginal conditions having greater ($P < 0.01$) CP content, compared with fields experiencing good or excellent growing conditions. A greater number of producers were using silage piles (79.9 percent), compared with bunkers (17.5 percent) or silage bags (2.6 percent), and 76 percent of the horizontal silos were uncovered. Spoilage was greater ($P < 0.04$) in silos that were uncovered (6.8 inches), compared with those that were covered (2.5 inches). Kernel processing resulted in less variability in particle size, compared with silages processed without a kernel processor. Poor silage face management can result in excess dry-matter loss of forages after silage feeding has begun. Producers are encouraged to evaluate factors influencing quality and take steps to maximize return on their corn silage investment.

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Introduction

The amount of corn being harvested as silage increased by 10,000 acres between 2010 and 2017 (U.S. Department of Agriculture-National Agricultural Statistics Service 2018) due to the introduction of new corn varieties better adapted for the climate of northern and western North Dakota. The Corn Silage Quality Program was initiated to determine factors contributing to variation in corn silage quality and to encourage interaction between Extension personnel and livestock producers.

Experimental Procedures

Extension agents from 29 counties collected samples from 171 operations (Figure 1). Samples were collected from five locations along the feeding face of the silo. For each sample, a data collection card (Figure 2) was filled out. The card detailed variety type, relative maturity, and growing and harvesting conditions, as well as silage management and feeding intentions.

A 2-gallon bag of sample was submitted to NDSU for analysis of dry matter, ash, crude protein, neutral detergent fiber, acid detergent fiber and in vitro dry-matter digestibility. The total digestible nutrients (TDN) was calculated using the formula:

$$TDN\% = 87.84 - (ADF\% \times 0.70)$$

Following analysis, individual reports of the nutrient concentrations of sampled silage were distributed to participating producers.

Each sample was processed through a Penn State Particle Separator (PSPS), which consists of a series of three sieves stacked on top of a bottom pan (Heinrichs, 1996). A representative sample of silage was placed in the upper sieve of

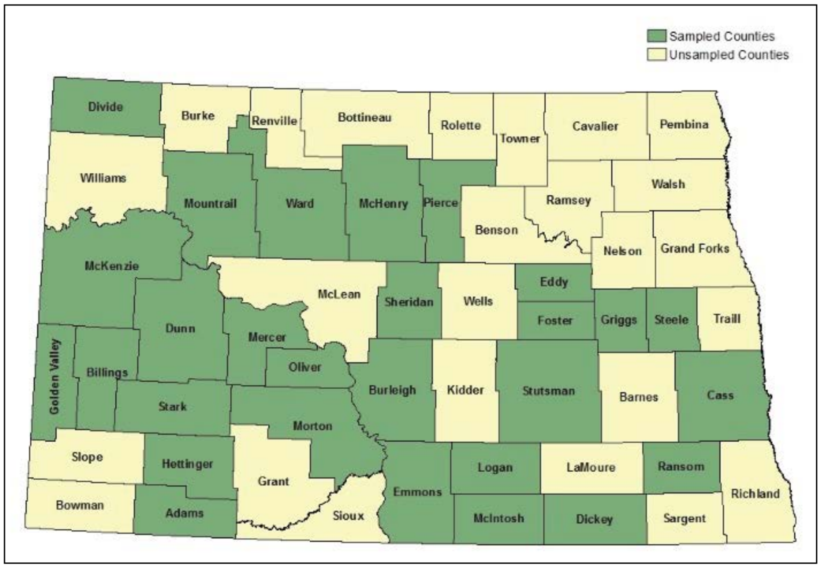
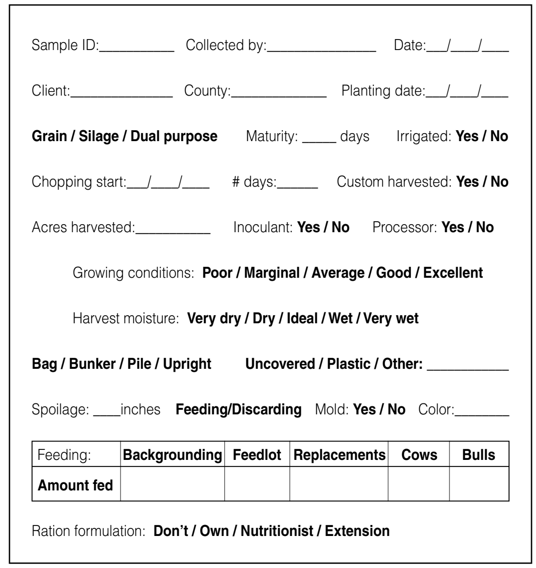


Figure 1. Map of participating counties.



Sample ID:________ Collected by:____________ Date:__/__/__

Client:__________ County:__________ Planting date:__/__/__

Grain / Silage / Dual purpose Maturity: ____ days Irrigated: **Yes / No**

Chopping start:__/__/__ # days:_____ Custom harvested: **Yes / No**

Acres harvested:________ Inoculant: **Yes / No** Processor: **Yes / No**

Growing conditions: **Poor / Marginal / Average / Good / Excellent**

Harvest moisture: **Very dry / Dry / Ideal / Wet / Very wet**

Bag / Bunker / Pile / Upright **Uncovered / Plastic / Other:** ________

Spoilage: ___inches **Feeding/Discarding** Mold: **Yes / No** Color:______

Feeding:	**Backgrounding**	**Feedlot**	**Replacements**	**Cows**	**Bulls**
Amount fed					

Ration formulation: **Don't / Own / Nutritionist / Extension**

Figure 2. Data collection card.

the PSPS, which then was shaken five times and rotated a one-quarter turn. This process was repeated seven times, for a total of 40 shakes. The proportion of silage (as-fed basis) remaining above the 0.75-inch sieve (**Upper**), 0.31-inch sieve (**Middle**), 0.16-inch sieve (**Lower**) and in the bottom pan (**Bottom**) then was calculated on an as-fed basis.

The MEANS procedure of SAS was used to characterize the sample population based on survey responses collected on the data collection cards. Data then were analyzed using the GLM procedure of SAS for the effects of producer-defined growing conditions (poor, marginal, average, good, excellent), variety relative maturity (less than 90, 90 to 100 and greater than100 days), and whether piles were covered (yes or no) and kernel processing occurred (yes or no).

Results and Discussion

Wide variation in planting and harvest dates and sample nutrient composition was present in samples collected (Table 1).

The crude protein concentration of silages was influenced by producer-defined growing conditions, with those fields growing in poor or marginal conditions having a greater ($P < 0.01$) CP concentration than fields experiencing good or excellent growing conditions (Figure 3). This observation is likely due to silages

Table 1. Nutrient content of corn silage samples.

Item	Average	Minimum	Maximum
Planting date	—	4/5/16	6/21/16
Harvest date	—	8/19/16	10/20/16
Dry matter, %	36.6	21.3	71.8
Crude protein, %	7.2	5.3	10.3
Neutral detergent fiber, %	44.2	30.5	58.2
Total digestible nutrients, %	70.0	62.4	76.0
In vitro dry-matter digestibility, %	73.4	55.5	80.9

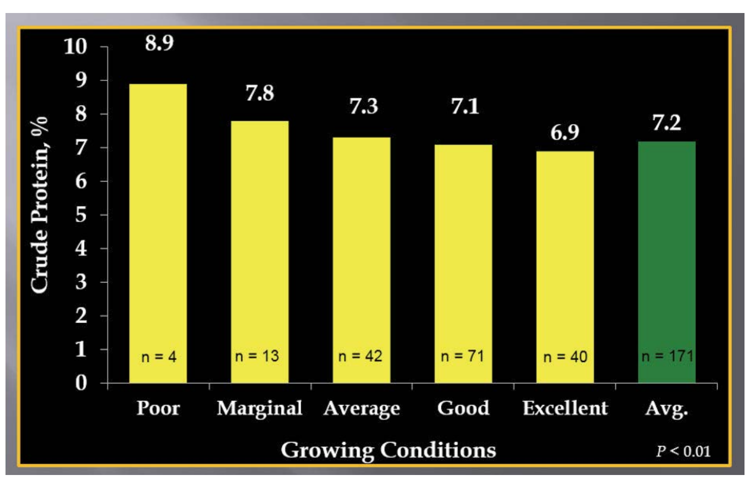


Figure 3. Concentrations of crude protein in sampled silage based on producer-defined growing conditions.

grown in poor conditions having a greater proportion of leaf and stalk (higher protein components) and less grain (low protein component), compared with silages experiencing good or excellent growing conditions.

Most producers planted silage-type corn (73.9 percent), compared with grain (13.4 percent) or dual-purpose varieties (12.7 percent) and the dry-matter (DM) concentration of grain varieties (41.4 percent) was greater ($P < 0.01$) than it was for silage varieties (35.6 percent). Similarly, shorter-day varieties (relative maturity less than 90 days; 40.8 percent) had greater DM concentration, compared with longer day varieties (35.5 percent for 90 to 100 days and 35.2 percent for greater than 100-day relative maturity).

Differences in the silage DM concentration among varieties and relative maturities highlight the importance of determining whole-plant DM concentration leading up to chopping. Traditional indicators of when to start chopping silage (target: 50 percent milk line) can be deceiving with different silage hybrids and maturities, so the recommendation is to target harvest based on whole-plant dry matter (60 to 70 percent moisture for horizontal silos/piles) to ensure optimal silage quality, packing, handling and feeding characteristics.

A greater number of producers were using silage piles (79.9 percent), compared with bunkers (17.5 percent) or silage bags (2.6 percent), and 76 percent of the horizontal silos were uncovered. Covering horizontal silos does offer an opportunity to reduce feed loss because spoilage was greater ($P < 0.04$) in silos that were uncovered (6.8 inches) than in those that were covered (2.5 inches).

What also is important to remember is that the actual spoilage likely started as more than 1 foot of fresh chopped forage, and that the spoilage layer can account for more than 10 percent DM loss in uncovered piles (McLaughlin et al., 1978). Producers are encouraged to compare the cost of silage covering, management and disposal of silage covers (plastic, membrane, etc.) with the feed losses associated with not covering their silos.

New alternatives to plastic coverings are available. These coverings further reduce feed losses associated with spoilage and other anti-quality factors (Borreani and Tabacco, 2014).

Kernel processors can be included on choppers to crack corn kernels and reduce the particle size of the stalk and cobs as they are being chopped, resulting in less feed sorting, greater intake and greater starch digestibility (Johnson et al., 2003; Andrae et al., 2001).

When comparing particle size determined with the PSPS, those samples that were harvested with a kernel processor had a greater ($P < 0.001$) proportion of feed remaining in the middle screen, compared with samples chopped without a kernel processor (Figure 4). In contrast, silage harvested without a kernel processor had a greater ($P < 0.001$) proportion of feed in the top and lower screens, compared with silage harvested with a kernel processor.

Taken together, these observations indicate a greater variability in particle size of silages harvested without a kernel processor. In addition, harvesting silage with a kernel processor resulted in a greater proportion of silage particles between 0.31 and 0.75 inch, which is a more optimal size for digestibility.

A wide variety of management of silage faces occurred at the time of sample collection (Figure 5). Silage requires an anaerobic environment for proper fermentation, preservation and storage. Secondary heating and subsequent DM loss can occur once silage is being fed and exposed to air (Kung, 2010).

To combat DM losses during feeding, producers are encouraged to keep the silage face as straight as possible, remove at least 6 inches of silage from the entire feeding face of the silo on a daily basis and minimize loose silage on the face of piles. In addition, producers are encouraged to use anticipated silage feed-

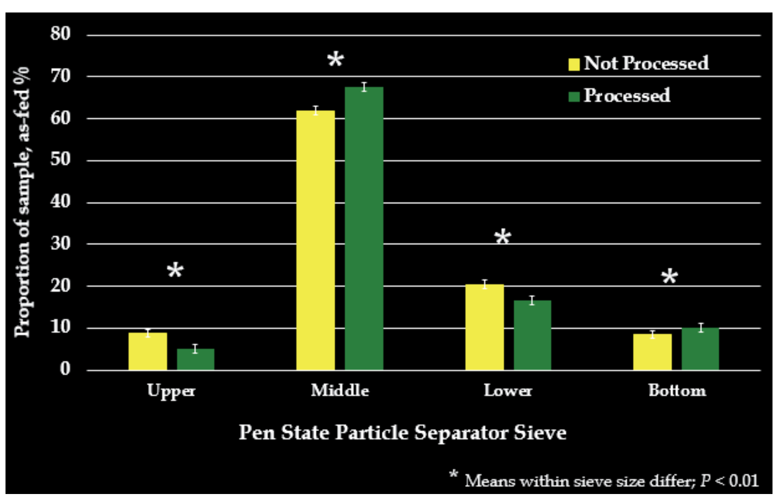


Figure 4. Effect of kernel processing on silage particle size. Particle size remaining on the Penn State Particle Separator upper sieve is greater than 0.75 inch; on the middle sieve, it is less than 0.75 to 0.31 inch; on the lower sieve, it is less than 0.031 to 0.16 inch; and in the lower pan, it is less than 0.16 inch.

ing intentions and recommended minimum face removal amounts to determine appropriate silage pile dimensions before starting the harvest.

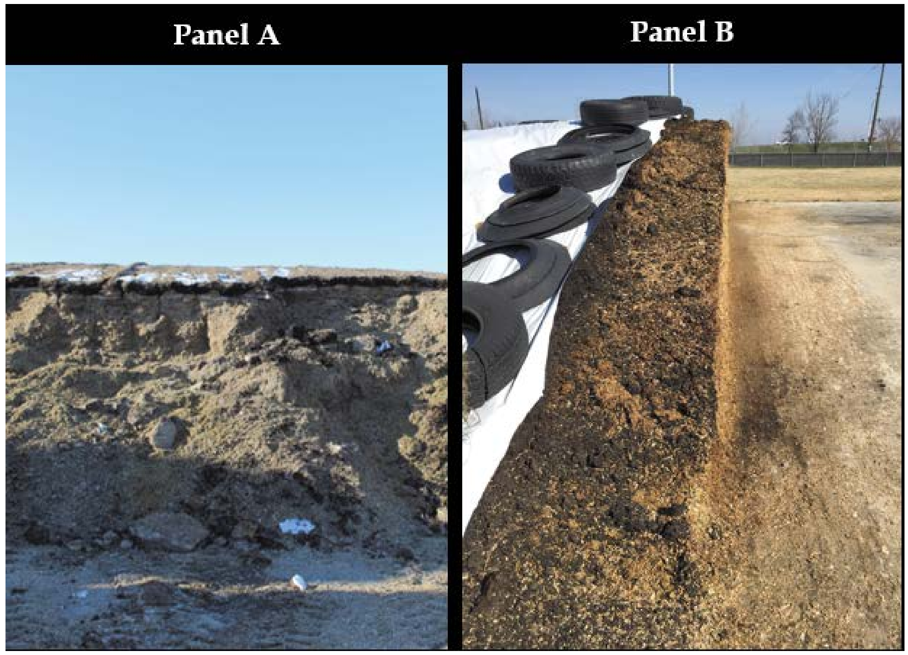


Figure 5. Examples of variation in silage face management. Panel A represents a pile in which excess loose silage is present along the silage face, offering opportunity for secondary heating and DM loss. Panel B represents a pile where a fixed amount of silage is removed from the entire face on a daily basis and no loose silage is present in front of the pile, offering very little opportunity for additional DM loss.

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Impacts of flax on female reproductive traits when supplemented prior to breeding in sheep

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The objective of this study was to determine the effect of flax supplementation on reproductive parameters in multiparous ewes. The results indicate offering Flaxlic Sheep tubs will not alter the parameters of reproductive efficiency, including pregnancy rate, lambing rate, and prolificacy rate.

Summary

The objective of this study was to evaluate the effectiveness of flax supplementation on plasma fatty acid profile, serum progesterone concentration, and first-cycle pregnancy parameters. Two hundred forty multiparous Rambouillet ewes were assigned randomly to 24 pens (10 ewes/pen; n = 12). Ewes were fed a diet consisting of chopped hay that was balanced for flushing for 35 days. Pens were assigned randomly to one of two treatments for the 35-day feeding period: Flaxlic Sheep Tub (FLX) (intake= 5.32 ounces/ewe/day) or control (CON). Ewes were weighed on consecutive days at the beginning (days zero and 1) and end (days 34 and 35) of the study, as well as once every seven days to monitor weight gain. Blood samples were taken weekly on a subset of five ewes for the evaluation of circulating serum progesterone and omega-3 fatty acid concentrations. On day 18, intact male rams were placed in adjacent pens to stimulate estrus. After the dietary treatment protocol, ewes were comingled and placed in a pasture for breeding. At lambing, birthweight, birth type, and sex were recorded.

No differences were observed for initial weights and body condition score (BCS) ($P \geq 0.45$; 156.3 pounds and 3.1, respectively) or final weights and BCS ($P \geq 0.23$; 153.9 pounds and 3, respectively). No differences were observed ($P \geq 0.41$) for pregnancy rate (63.3 percent ± 4.7), prolificacy rate (152.6 percent ± 6.6), or lambing rates (95.8 percent ± 7.06) between CON and FLX treatments. No treatment by day interactions or treatment effects were observed ($P \geq 0.28$) for serum progesterone concentration. Our results are similar to results of studies in cattle, which demonstrated that flax did not have an effect on female reproductive traits. However, our results are in contrast with flax research conducted in other multiple-bearing species such as rabbits and rats.

Introduction

Fertility can be improved prior to breeding in sheep by improving nutritional management. This can be done by improving the ration in a flushing protocol. Flushing is a sudden increase in nutrition to facilitate follicular growth. This leads to the production of more eggs to ovulate and the potential for more lambs at birth. The addition of flaxseed to a flushing protocol has the potential to further enhance the effects of flushing.

Flaxseed supplements two important fatty acids: Alpha-linolenic acid (ALA; C18:3 n-3), an omega-3 fatty acid, and linoleic acid (LA: C18:2 n-6), an omega-6 fatty acid. Of the total fats in flax oil, 57 percent is ALA and 16 percent is LA (Morris, 2007).

Flaxseed has been shown to increase ALA and LA content in the milk of sheep, inferring flaxseed's fatty acids can be absorbed during digestion, enter the blood, and be transferred to the milk of sheep (Luna et al., 2008) and cows (Neveu et al., 2014). Additionally, flaxseed has been shown to increase ovulations in flax-fed litter-bearing species (Scholljegerdes et al., 2011; Abayasekara and Wathes, 1999; Trujillo and Broughton, 1995).

ALA and LA are precursors for prostaglandin synthesis. Increasing these fatty acids in the diet with the addition of flaxseed may affect reproduction because they have been shown to be essential for these prostaglandin precursors, as well as for structural fats (Singh et al., 2011). Supplementation of flaxseed has been shown to increase the size of the corpus luteum and increase subsequent progesterone concentrations (Lessard et al., 2003; Petit and Twagiramungu, 2006).

The objective of the present study was to determine if supplementation of flaxseed prior to breeding in Rambouillet ewes would improve reproductive parameters. The Flaxlic Sheep Tub was utilized as the supplementation method. The inclusion of flax in the flushing protocol should increase omega-3 and omega-6 fatty acids in the diet and alter key reproductive hormone concentrations.

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[2]New Generation Supplements, Belle Fourche, S.D.

Experimental Procedures

Two hundred forty multiparous Rambouillet ewes were kept in 24 pens in groups of 10 (n = 12). Ewes in every other pen were given a Flaxlic Sheep Tub (FLX). The Flaxlic Sheep Tub included 21 percent ground flaxseed and 6.4 percent flaxseed oil, as well as soybean meal and beet molasses.

The flax tub contained at least 12 percent crude protein, 15 percent crude fat, a maximum of 2 percent crude fiber and 2.5 percent acid detergent fiber. In terms of mineral, calcium, phosphorus, cobalt, iodine, manganese, selenium and zinc were supplied. The flax tub also supplemented vitamins A, D and E. The control (CON) pens did not get a flax tub but were supplemented with minerals by top dressing the ration (Hettinger Sheep Mineral 16-8).

Ewes were fed a diet of chopped hay for 35 days. The diet was balanced for a 154-pound ewe at a flushing rate. The diet was altered throughout the study to account for weight changes, with the CON treatment receiving more of the basal diet than the FLX treatment (3.77 and 3.46 pounds per head per day, respectively).

Ewes were weighed weekly. Body condition score was taken at the beginning and end of the trial. Blood was collected by jugular venipuncture from five ewes of average weight from each group on each weigh day, for a total of 120 ewes per week, for progesterone and fatty acid analysis.

On day 17, 10 mature rams were placed alongside the ewes for fence line male contact to induce cycling. On day 35, flax tubs were removed, and the 24 groups were comingled on pasture and rams were introduced for breeding.

Prior to lambing, ewes were allocated randomly to indoor pens of 15 ewes per pen. Lambing occurred from Jan. 14 through Feb. 26, 2018. At lambing, lamb birthweight, birth type, and sex were recorded. Lambs were docked at 1 to 2 weeks of age. Male lambs were not castrated at this time.

At approximately 14 days of age, lambs were moved to an outside dry lot with their dams. They remained comingled in the outdoor pens until weaning. Weights were taken of lambs at approximately 60 days of age.

Results and Discussion

Initial weights and body condition score did not differ between treatment groups. As designed, the final weights and body conditions scores did not differ (Table 1). The ewes were managed across the 35-day feeding period to achieve this result, utilizing increased hay intake for the CON treatment to ensure any effects observed were due to the addition of flax, not merely due to the addition of the entire tub.

We found no treatment by day effects ($P > 0.05$). Additionally, no differences occurred between treatments ($P = 0.28$) for progesterone concentration, but a day effect was found ($P < 0.001$). Progesterone increased in both treatments on days 28 and 35 (0.83 and 1.45 nanograms per milliliter [ng/mL], respectively; $P < 0.001$). Ewes were considered to be cycling when circulating progesterone rose above 1 ng/mL.

We found no differences ($P \geq 0.41$) in lambing data between FLX and CON (Table 3). The goal of adding flaxseed was to increase synthesis of progesterone. No difference was found in lamb birthweight (FLX = 11.96 pounds CON = 11.71 pounds; P = 0.28). Because no difference was found between treatment groups in progesterone concentration, the lambing data supports the progesterone data suggesting minimal effects of feeding FLX.

These results are in contrast with multiple studies involving

Table 1. Initial and final weight data for FLX and CON treatments[1].

	Treatment			
Item	CON	FLX	SEM	*P*-Value[3]
Initial weight, lbs.	156.5	156.1	0.42	0.47
Initial BCS[2]	3.09	3.11	0.024	0.45
Final weight, lbs.	153.2	154.6	0.81	0.23
Final BCS	2.97	2.98	0.05	0.88

[1] FLX = Flaxlic tub supplemented ewes; CON = control ewes.
[2] Body condition score, on a scale of 1-5 (1 = extremely thin, 5 = obese).
[3] *P*-value for F-test across treatments (n = 12 for FLX and CON treatments).

Table 2. Influence of feeding flax on progesterone concentration in ewes.

	Day					
Item[1], ng/mL	0	7	14	21	28	35
FLX	0.2	0.15	0.22	0.18	0.99	1.50
CON	0.17	0.17	0.16	0.26	0.67	1.41
P-value	0.88	0.93	0.71	0.61	0.04*	0.55

[1] FLX- Flaxlic Tub; CON-Control group.
*Significant values ($P < 0.05$).

omega-3 fatty acid additions in a livestock ration (Ambrose et al., 2006; Petit et al., 2008; Scholljegerdes et al., 2014). However, the results were in agreement with studies such as Petit et al. (2008), who indicated no increase in oocyte production in flax-fed dairy cattle.

Table 3. Influence of feeding flax on lambing data in ewes[1].

	Treatment			
Item[2]	CON	FLX	SEM	*P*-Value[3]
Pregnancy rate, %	61.7	65.0	4.71	0.62
Prolificacy rate, %	150.2	155.0	6.6	0.61
Lambing rate, %	91.7	100.0	7.06	0.41

[1] FLX = Flaxlic tub supplemented ewes; CON = control ewes.
[2] Pregnancy = percentage pregnant first cycle per ewe treated; Prolificacy = lambs first cycle per ewe lambed; Lambing rate = lambs first cycle per ewe treated.
[3] *P*-value for F-test across treatments (n = 12 for FLX and CON treatments).

Acknowledgments

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Effect of progesterone-infused controlled internal drug-releasing (CIDR) device and timing of gonadotropin stimulation using P.G. 600 on reproductive success in anestrous ewes

Reid Redden[1], Tammi Neville[3], Danielle Black[3], Melissa Crosswhite[2] and Carl Dahlen[3]

The objective of this study was to evaluate the effects of using CIDR alone or in combination with P.G. 600 one day before or at the time of CIDR removal on reproductive performance of anestrous ewes. Treating ewes with CIDRs resulted in a greater proportion of ewes becoming pregnant and lambing earlier in the lambing season. Additional benefits were observed when P.G. 600 was used in combination with a CIDR, resulting in more lambs being born in the first 10 days of the lambing season.

Summary

Objectives of this study were to determine the effects of controlled internal drug-releasing (CIDR) devices in combination with P.G. 600 use at CIDR removal or one day before CIDR removal on days to lambing, lambing rate and prolificacy in seasonally anestrous ewes. Multiparous ewes (n = 414) were assigned randomly to one of four treatments: untreated (**U**, n = 122), seven-day CIDR (**C**, n = 97), seven-day CIDR plus P.G. 600 at CIDR removal (**CPG0**, n = 97) and seven-day CIDR plus P.G. 600 one day before CIDR removal (**CPG-1**, n = 98). Rams (n = 15) were joined with ewes immediately after CIDR removal and remained with ewes for a 21-day breeding period. Data collected included days to lambing post-CIDR removal, lambing rate (number of lambs/ewe exposed) and prolificacy (number of lambs/ewe lambing).

Ewes receiving CIDR and P.G. 600 (CPG0 and CPG-1) lambed earlier ($P < 0.001$) in the lambing season, compared with untreated ewes. Prolificacy was similar among all treatments for the first 10 days of the lambing season ($P = 0.86$) and overall ($P = 0.80$). In the first 10 days of the lambing season, the lambing rate was greatest ($P < 0.05$) for CPG0 and CPG-1 ewes, compared with CIDR ewes, which had a greater ($P < 0.001$) lambing rate, compared with untreated ewes. The overall lambing rate was increased ($P < 0.001$) in all treatments utilizing CIDR devices, compared with untreated ewes, and no difference ($P > 0.76$) was seen due to P.G. 600 use. The combination of CIDR and P.G. 600 may be beneficial in shortening the lambing season and increasing overall productivity of the flock in out-of-season breeding scenarios.

Introduction

Sheep producers have limited reproductive management options because sheep are seasonal breeders. Progesterone-infused controlled internal drug-releasing (CIDR) devices have been shown to induce estrus in ewes during the anestrous period (Knights et al., 2001).

In 2009, CIDRs were approved for use to induce estrus in seasonally anestrous ewes by the Food and Drug Administration. However, the overall fertility of ewes treated with CIDRs during the anestrous period has been less than fertility of ewes during the normal breeding season (Crosby et al., 1991). As a result, the cost-effectiveness of this tool has been less than ideal for commercial sheep producers.

Various gonadotropins commonly are given at CIDR removal to induce estrus in ewes during the anestrous season. A commonly used product, P.G. 600, is a mixture of equine chorionic gonadotropin (FSH-like activity) and human chorionic gonadotropin (LH-like activity) and is approved for inducing estrus in swine (Britt et al., 1989).

Limited data are available on the efficacy of P.G. 600 with regard to timing of use and dosage (Safranski et al., 1992; Jabbar et al., 1994; Windorski et al., 2008) and the impact of P.G. 600 around the time of short-term CIDR removal. Jackson et al. (2014) demonstrated fewer days to estrus using five-day CIDR and five-day CIDR plus GnRH (10 milligrams [mg] of dinoprost tromethamine) at CIDR removal, compared with untreated control ewes during the normal breeding season.

Data from D'Souza et al. (2014) showed P.G. 600 (3 milliliters [mL]) given at CIDR removal (at day five) did not improve fertility (Exp. 1),

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compared with CIDR alone. However, when P.G. 600 was given one day prior to CIDR removal (at five days), the pregnancy and prolificacy rate were improved (Exp. 2), compared with CIDR alone in anestrous ewes.

However, data comparing the effects of a CIDR with P.G. 600 administered at the time of CIDR removal or one day before removal are lacking. Therefore, the objectives of this study were to evaluate the effects of using CIDR alone, or in combination with P.G. 600 one day before or at the time of CIDR removal, on reproductive performance of anestrous ewes.

Experimental Procedures

Protocols described here were approved by the North Dakota State University Institutional Animal Care and Use Committee. This study was conducted on a commercial sheep operation in central North Dakota. Multiparous ewes (n = 414) all were managed similarly for the duration of the research project. During the breeding period, ewes were grazing native prairie grass.

In late July, all ewes were assigned a body condition score by a trained technician. Ewes were assigned randomly to one of four treatments: untreated (U, n = 122), seven-day CIDR insert (EAZI-BREED CIDR Sheep Insert, 0.3 g P4, Zoetis Animal Health, Florham Park, N.J.; C; n = 97), seven-day CIDR plus 3 mL P.G. 600 (Merck Animal Health, Intervet Inc., Madison, N.J.) at removal (CPG0, n = 97), and seven-day CIDR plus P.G. 600 one day prior to CIDR removal (CPG-1, n = 98). Rams (n = 15) were joined with ewes immediately after CIDR removal and remained with ewes for a 21-day breeding period.

Data collected included date of birth in the lambing season, lambing rate (number of lambs/ewe exposed) and prolificacy (number of lambs/ewe lambing). The latter two measures of interest were further broken down to represent ewes that lambed in the first 10 days of lambing and those that did not lamb during the same time period.

The GLM procedure (SAS Inst. Inc.) was used to analyze noncategorical data, and procedure GENMOD (SAS Inst. Inc., Cary, N.C.) was used to analyze all categorical data. Treatment and body condition score were included as fixed effects in procedure GLM analysis. Means were separated by using the LSMEANS function of SAS when a protected F-test ($P \le 0.10$) was detected by ANOVA. Differences were determined at $P \le 0.05$.

Results and Discussion

Treatment with CIDR alone or in combination with P.G. 600 resulted in more ($P < 0.001$) anestrous ewes becoming pregnant and subsequently giving birth, compared with untreated ewes (Table 1). Similarly, Safranski et al. (1992) reported an increase in the proportion of ewes lambing with the use of MGA (similar mode of action to CIDR) alone or in conjunction with P.G. 600.

In contrast, in a small experiment, Knights et al. (2015) observed fewer ewes lambing after receiving P.G. 600 at CIDR removal, compared with ewes receiving only a CIDR for five days. Our results indicate that producers can use CIDR inserts in a seven-day protocol with or without P.G. 600 to enhance the proportion of ewes that become pregnant to out-of-season breeding.

Table 1. Effect of progesterone-infused controlled internal drug-releasing device (CIDR) and timing of gonadotropin stimulation using P.G. 600 on lambing rate and prolificacy in anestrous ewes.

	Treatments[1]					
Item	U	C	CPG-1	CPG0	SEM	*P*-Value[2]
n	122	97	97	98		
BCS	2.66	2.63	2.65	2.62		
Lambing rate, %[3]						
First 10 days lambing season[4]	0.8[a]	42.3[b]	59.2[c]	54.1[c]	4.25	<0.001
Overall	49.2[a]	73.2[b]	74.5[b]	72.5[b]	4.67	<0.001
Prolificacy, no.[5]						
First 10 days lambing season	2.00	1.78	1.74	1.68	0.63	0.86
Overall	1.73	1.70	1.67	1.63	0.08	0.80

[1]Treatments: untreated (U, n = 122), seven-day CIDR (C, n = 97), seven-day CIDR plus P.G. 600 at removal (CPG0, n = 97) and seven-day CIDR plus P.G. 600 one day prior to CIDR removal (CPG-1, n = 98).

[2]*P*-value is for F-tests of the mean.

[3]Lambing rate = Lambs born per ewe exposed.

[4]First service period is defined as the ewes that lambed in first 10 days of lambing season.

[5]Prolificacy = Lambs born per ewe lambing.

Using P.G. 600 in combination with a CIDR (CPG0 and CPG-1 treatments) resulted in a greater proportion ($P < 0.05$) of ewes lambing in the first 10 days of the lambing season, compared with CIDR alone, which had more ($P < 0.001$) ewes lambing in the first 10 days of the lambing season, compared with untreated ewes.

Further analysis revealed that lambs in the CIDR treatment were born 11 days earlier ($P < 0.001$), compared with untreated ewes (Figure 1), and that adding P.G. 600 to the CIDR treatment (CPG0 and CPG-1 treatments) resulted in lambs being born an additional three to four days earlier ($P \leq 0.03$) in the lambing season, compared with CIDR treatment alone.

Similarly, our lab previously observed that ewes in the transition period (August through October, after the summer solstice) treated with five-day CIDR lambed nine days earlier in the lambing season, compared with untreated ewes (Jackson et al., 2014), but P.G. 600 administration was not evaluated.

Safranski et al. (1992) and Windorski (2008) noted decreased days to lambing with the use of Melengestrol Acetate (**MGA**) in conjunction with P.G. 600 or alone. However, when D'Souza et al. (2014) evaluated the addition of P.G. 600 at the time of, or one day before CIDR removal in a five-day protocol, they did not observe an overall advantage in lamb age, compared with CIDR treatment alone.

Our results indicate a clear advantage in lamb age and the proportion of lambs born early in the lambing season after CIDR administration and a small additional advantage with the addition of P.G. 600 to a CIDR in an out-of-season breeding protocol.

Prolificacy (number of lambs born per lambing) was similar among all treatments for the first 10 days of the lambing season ($P = 0.86$) and overall ($P = 0.80$). Other researchers (Knights et al., 2015; Jackson et al., 2014; Windorski et al., 2008; Jabbar et al., 1994; Safranski et al., 1992) also noted no differences in prolificacy after treatment with progesterone or progesteronelike products, or with the addition of P.G. 600 to progestin-based protocols.

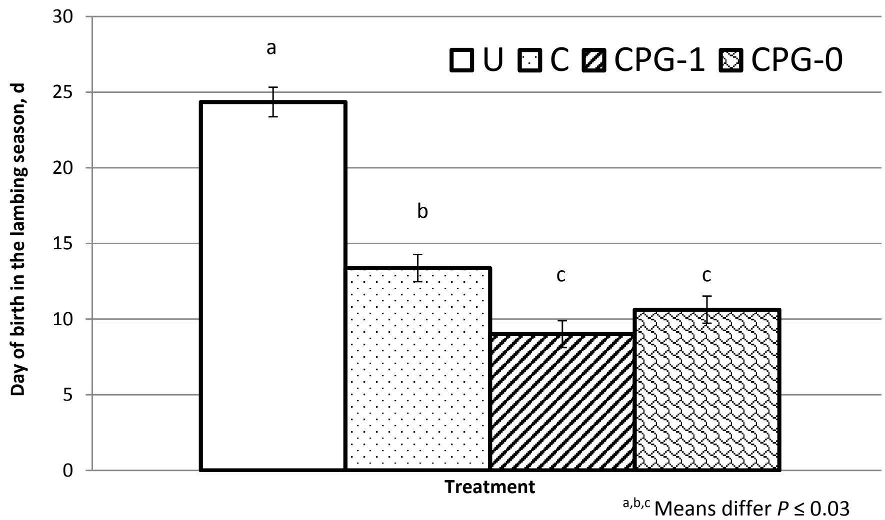

Figure 1. Effect of progesterone-infused controlled internal drug-releasing device (CIDR) and timing of gonadotropin stimulation using P.G. 600 on day of birth in the lambing season in anestrous ewes. Treatments: untreated (U, n = 122), seven-day CIDR (C, n = 97), seven-day CIDR plus P.G. 600 at removal (CPG0, n = 97) and seven-day CIDR plus P.G. 600 one day prior to CIDR removal (CPG-1, n = 98). a, b and c means differ $P \leq 0.03$.

However, D'Souza et al. (2014) did observe a tendency for increased prolificacy when P.G. 600 was administered at the time of CIDR removal, but not when administered one day before removal. Based on our results, we would not anticipate an improvement in out-of-season breeding prolificacy after CIDR administration with or without P.G. 600 administration.

Days to lambing was decreased by 13 days with the use of CIDR, and further decreased by 3.5 days with the use of P.G. 600. A 40 percent increase in the lambing rate was noted with the use of CIDR during the first 10 days of the lambing season, which was further increased by another 14 percent with the use of P.G. 600. The combination of CIDR and P.G. 600 may be beneficial in increasing the number of ewes lambing and increasing overall productivity in an out-of-season breeding scenario.

Acknowledgments

Appreciation is expressed to Brent Stroh and his family for supplying sheep and labor to conduct this research project.

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NDSU BullTest Project

Sarah Underdahl[1], Charles Stoltenow[2] and Carl Dahlen[1]

We developed a system to monitor results of bull testing activity on producer operations. Simple data collected at the time of bull testing quantified the reasons for failing breeding soundness examinations and documented that failure rates were greater for yearling than mature bulls. More yearling bulls failed because of semen morphology issues, compared with mature bulls, whereas more mature bulls failed because of penile defects, compared with yearling bulls. In both cases, however, major hindrances to breeding success would not have been observed if examinations were not conducted.

Summary

During a two-year period, data were collected to summarize incidence and reasons for failure of reproductive soundness examinations in yearling and mature beef bulls. Upon completion of examinations, participating veterinarians completed the BullTest card by indicating the number of yearling and mature bulls evaluated and the number of bulls in each age class that failed the examination. Examination failures were compared among bull ages and further classified by indicating the number of bulls failing for each of the following reasons: semen motility, semen morphology, excess white blood cells present in ejaculate, penile injury/defects, wart proliferation, feet and leg conformation, scrotal circumference and "other." In addition, practitioners indicated whether the test was the initial evaluation of bulls or a retest. Data were reported by five veterinary clinics and included 14,698 bulls in 1,374 groups. The overall failure rate for groups of yearling bulls (22.1 ± 1.2 percent) was greater ($P < 0.01$) than that of mature bulls (11.6 ± 0.8 percent). A greater ($P < 0.01$) proportion of yearling and mature bulls that were retested failed examinations, compared with those in their initial examination. Failure rates were similar ($P = 0.62$) among groups of yearling bulls tested as part of a breeding herd (20.9 ± 18 percent) or production sale (23.9 ± 2.6 percent). A greater ($P \leq 0.02$) proportion of yearling bull failures were related to semen morphology or penile warts, compared with mature bulls, whereas a greater ($P < 0.01$) proportion of mature bull failures were related to other penile injuries/defects or issues with feet and leg conformation. The BullTest system provided an excellent platform to summarize results of pre-breeding reproductive evaluations in beef bulls.

Introduction

Breeding soundness exams (BSE) provide beef producers with an indication of the reproductive potential of their herd sires. Components of a BSE can have a direct impact on fertility of bulls (Waldner et al., 2010), and we recommend that veterinarians perform a BSE each breeding season to identify bulls with potentially reduced fertility who need to be culled from the herd.

Physical characteristics of each bull, such as feet and legs, penile structure and scrotal circumference, are assessed and can be used as an indicator of sexual maturity in young bulls (Lunstra et al., 2003). In addition, sperm motility and morphology are analyzed and scored against minimum requirements to pass the BSE.

The current requirements for motility are a minimum of 30 percent motile sperm (Society for Theriogenology, 1993). Abnormal sperm morphology can be described as sperm that do not adhere to the physical structure of normal sperm. Examples of abnormal sperm may include coiled tails, detached heads and proximal droplets, and the minimum standard that a bull must meet is greater than 70 percent morphologically normal sperm (Society for Theriogenology, 1993).

The BullTest concept of data collection was developed at the request of veterinary clinics participating in the PregCard data reporting system. Clinicians desired a method of summarizing and reporting practice area results from the thousands of BSE and semen evaluations they conduct every year. These data also could be combined from multiple clinics to gain insights into trends across the state and region.

Focus-group sessions of veterinarians were held to determine appropriate and relevant data fields that should be included in the reporting system. These sessions helped us determine the fields of

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interest for the BullTest cards would include specific reasons for failure, whether the test was a simple semen test or BSE, and whether the test was for sale bulls or a herd test, with each card containing fields for yearling and mature bulls.

The BullTest data reporting system aimed to fill the void for veterinarians by combining reproductive exam data from across North Dakota, providing a platform for discussion among beef producers and their veterinarians, and, ultimately, provide data summaries to the beef industry regarding the importance of bull health and factors affecting male reproduction.

Experimental Procedures

At the request of veterinarians, the BullTest reporting system was developed, and focus-group sessions of veterinarians were held to determine appropriate and relevant data fields. The final BullTest card (Figure 1) emerged as a 4- by 5½-inch preprinted, postage-paid postcard that was completed after conducting examinations on groups of bulls. Cards were distributed to veterinary clinics for completion after pregnancy determinations during the spring-summer of 2014 and 2015.

During a two-year period, data were collected to summarize incidence and reasons for failure of reproductive soundness examinations in yearling and mature beef bulls. Upon completion of examinations, participating veterinarians completed the BullTest card by indicating the number of yearling and mature bulls evaluated and the number of bulls in each age class that failed the examination.

Examination failures were classified further by indicating the number of bulls failing for each of the following reasons: semen motility, semen morphology, excess white blood cells present in ejaculate, penile injury/defects, wart proliferation, feet and leg conformation, scrotal circumference and "other." In addition, practitioners indicated the type of examination conducted (simple semen exam or full BSE), whether the test was for a breeding herd or production sale, and whether the test was the initial evaluation of bulls or a retest.

The completed BullTest cards were mailed to NDSU and manually entered into the BullTest database. Data were analyzed using the GLM procedure of SAS, with card as the experimental unit. Additional models compared the failure rates and reasons for failure among yearling and mature bulls, and effects were considered significant at $P < 0.05$.

Clinic:_________ Client:__________ Date:___/____/____

ND / SD / MT / MN County:______________________

Sale / Herd **Semen / BSE**

Retest? **Y / N**		Bull Age	
Item		Yearling	Mature
Total Tested			
# Failed			
Reason for Failure	Motility		
	Morphology		
	WBC's		
	Penis		
	Warts		
	Feet & Legs		
	Scrotal Circ.		
	Other		

Comments:

Figure 1. BullTest card.

Results and Discussion

Data were reported by five veterinary clinics and included 14,698 bulls in 1,374 groups (Table 1). The number of bulls reported in each group ranged from one to 228 (mean = 10.7 ± 0.43; median = 6). Failure rates were similar ($P = 0.62$) among groups of yearling bulls tested as part of a breeding herd (20.9 ± 18 percent) or production sale (23.9 ± 2.6 percent). The overall failure rate for groups of yearling bulls (22.1 ±1.2 percent) was greater ($P < 0.01$) than that of mature bulls (11.6 ± 0.8 percent).

For each group, the proportion of bulls failing the examination and the proportion of bulls failing for each specific reason were calculated. A greater ($P < 0.01$) proportion of yearling bulls that were retested (39.5 ± 3.6 percent) failed examinations, compared with those in their initial examination (18.2 ± 1.8 percent). Similarly, a greater ($P < 0.01$) proportion of mature bulls that were retested (38.6 ± 2.7 percent) failed examinations, compared with those in their initial examination (9.4 ± 0.7 percent).

The incidence of bulls failing a second examination provide producers with benchmarking data of what they can expect when deciding whether to retest bulls of different ages that initially failed their examination. However, depending on the reason for failure, retesting may not be warranted, so further consultation with your veterinarian is recommended.

When specific reasons for failure were compared among yearling and mature bulls, several areas of divergence were observed (Figure 2). A greater ($P \leq 0.02$) proportion of yearling bull failures were related to semen morphology or penile warts, compared with mature bulls, whereas a greater ($P < 0.01$) proportion

Table 1: Responses to BullTest for two years.

Item	Year 1	Year 2	Total
Total cards, n	529	845	1,374
Total bulls, n	5,826	8,872	14,698
Bulls per group, n	11.0	10.5	10.7
Did not pass, n	660	966	1,626

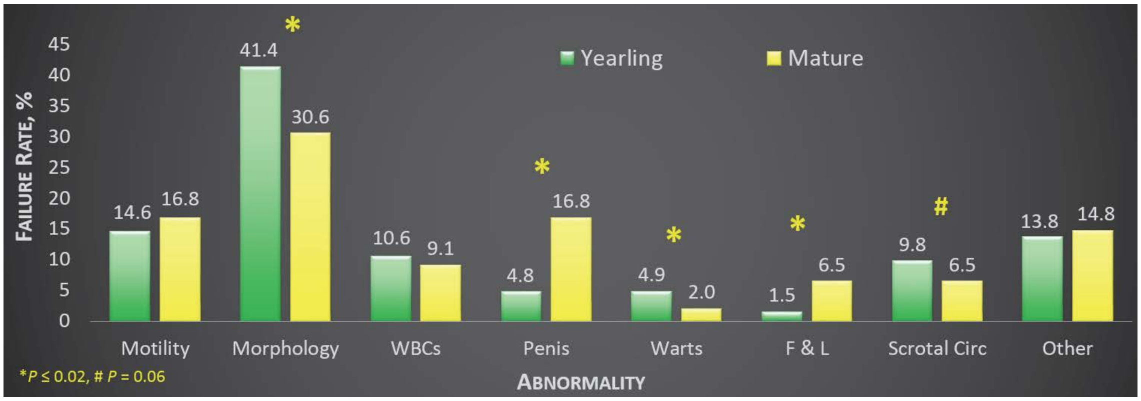

Figure 2. Comparison of reasons for breeding soundness exam failures among yearling and mature bulls.

of mature bull failures were related to other penile injuries/defects or issues with feet and leg conformation. However, in both cases, major hindrances to breeding success were identified that would not have been observed if examinations were not conducted.

The BullTest data collection platform provided an excellent method to summarize results of pre-breeding reproductive evaluations in beef bulls. Producers and veterinarians can utilize these data for benchmarking their herd performance and understanding the fundamental differences anticipated when testing yearling and mature bulls.

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NDSU Beef Teaching and Research Unit cattle: Genetic makeup resembles current industry production animals

Lauren Hulsman Hanna[1], Taylor Zimprich[1], Kara Bernston[1] and William Ogdahl[1]

The NDSU Beef Teaching and Research Unit (Beef Unit) supports the land-grant mission of NDSU by providing research, teaching and outreach opportunities with its cow herd. Keeping animals relevant to current industry animals for comparison purposes is an important part of this mission. This article demonstrates that the current Angus and Simmental herds maintained at the Beef Unit have genetic relationships to influential animals in each breed, as well as current key animals in the industry.

Summary

Pedigree analysis can be used to understand genetic similarity within a herd, as well as its genetic resemblance to key industry animals if needed. The objective of this study was to calculate and compare genetic relationships of the current Beef Unit's Angus and Simmental herds, as well as compare how they genetically relate to key individuals in the respective breeds. Complete pedigrees were built for each herd (n = 38,107 and 3,626 for Angus and Simmental, respectively), with the oldest animals born in 1834 and 1930 for Angus and Simmental pedigrees, respectively. These pedigrees were used to calculate relationship and inbreeding coefficients among the Beef Unit's current Angus and Simmental cow herds, as well as to key ancestors. Average relationships among herds and to key ancestors were less than a half-sibling relationship (i.e., less than 0.25) in all cases; however, instances did occur on an individual basis that animals assumed parent-offspring or full-sibling relatedness. Inbreeding coefficients were generally below 0.10 in both herds, indicating that genetic diversity was still present in both herds, while also maintaining genetic similarity to key industry animals.

Introduction

The NDSU Beef Teaching and Research Unit (Beef Unit) provides facilities and beef cattle to integrate research, teaching and Extension to serve the NDSU Beef Program, NDSU Animal Sciences and the community. In doing so, the goal of the Beef Unit is to strive constantly and consistently for improvement of beef cattle in stewardship, health and genetics.

In this regard, cattle utilized at the Beef Unit should have some resemblance to the current industry for that breed to ensure that research, teaching and Extension activities are applicable to stakeholders in North Dakota and surrounding regions. One method that can be used to investigate this "resemblance" is through the genetic relationship of the current herd to key industry animals utilizing pedigree analysis.

Through pedigree analysis, genetic parameter estimates based on additive gene action inheritance can be calculated and include relationship and inbreeding coefficients. By understanding genetic relationships through pedigree, we can understand an expected level of genetic similarity and, therefore, potential phenotypic performance similarities.

Pedigree analysis has an important role in the industry and within herds to retain breed standards while retaining an appropriate amount of genetic diversity, which can help with selection and mating of livestock. If two related animals are mated, they produce inbred offspring. The presence of inbreeding in an animal has a primary effect of increasing the homozygosity of that animal's genotypes, which can be beneficial for increasing uniform progeny produced by that animal.

Inbreeding in a population also increases the homozygosity of genotypes for the population, but inbreeding can result in more diverse performance within this population if animals inherit distinctly different alleles through inbreeding. Secondary and tertiary effects of inbreeding can lead to the expression of deleterious alleles and inbreeding depression, which may have negative impacts on herd performance.

Thus, the aim of herdsmen is to maintain an understanding of relationships and inbreeding coefficients of animals so they do not unknowingly produce negative results due to these effects. Therefore, the objective of this study was to calculate and compare genetic relationships among members of the current Beef

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Unit's Angus and Simmental herds, as well as compare how they genetically relate to key individuals in the respective breeds.

Procedures

Parentage records of current purebred Angus and Simmental females at the Beef Unit were identified, and registration numbers were compiled and sent to the respective breed association for complete pedigree records. Pedigree records received were formatted and compiled for each breed separately in a Microsoft Excel spreadsheet. Missing sire and dam information was coded as zero.

Information utilized as part of this project was registered name, registration number, birth year and gender. In the event that a birth year did not align with progeny records, steps were taken to adjust the birth year of that animal to be two years older than the oldest progeny record. Birth year was utilized to order the pedigree from oldest to youngest, as well as to look at trends of relationship and inbreeding through time.

Key ancestors were identified in both breeds based on the number of times that a sire or dam was present in the completed pedigree. Specifically, animals born in 1970 or later were identified for use. Bulls had to have 15 or more progeny, whereas cows had to have three or more progeny.

Furthermore, key sires were identified using the American Angus Association (AAA) Pathfinder search and utilized if they had progeny in the completed pedigree for the current Angus herd.

Lastly, key sires were identified in the American Simmental Association (ASA) by searching for purebred Simmental sires that produced the highest number of progeny between July 1, 2016, and June 30, 2017. If these Simmental sires were not present in the current pedigree, their pedigree records were incorporated to calculate relatedness to current herd animals.

Utilizing the complete pedigree, the additive genetic covariance (COV_{XY}) and relationship coefficient (R_{XY}) were calculated for each pair of animals (e.g., animals X and Y) and the inbreeding coefficient for each animal (F_X) utilizing the method described by Wright (1922) in R software (R Core Team, 2013). Scripts in R software were developed by G. Morota (personal communication) and modified by L. Hulsman Hanna. These scripts followed the equations of:

$$Relationship\ Coefficient\ (R_{XY}) = \frac{COV_{XY}}{\sqrt{(1+F_X)(1+F_Y)}}$$

and

$$Inbreeding\ Coefficient\ (F_X) = \frac{1}{2} * COV_{X's\ Parents}$$

The COV_{XY} between two animals can range from 0 (no additive genetic relationship) to 2 (complete additive genetic relationship; e.g., identical twins). Inbreeding levels can make two animals more or less similar genetically due to the alleles inherited; therefore, the R_{XY} corrects for this by incorporating the inbreeding coefficient (F_X).

The R_{XY} and F_X range from 0 to 1. Common genetic relationship levels when no inbreeding is present are given in Table 1. Results of the coefficients calculated were visualized in R software (R Core Team, 2013) using corrplot package (Wei and Simko, 2017) and scripts developed by L. Hulsman Hanna.

Results and Discussion

Angus Pedigree

Birth years for the entire pedigree ranged from 1834 to 2016; however, birth years prior to 1960 were prone to be incorrect. Therefore, trends are not reported on animals with birth years prior to this date.

The Angus pedigree for the current 33 cows at the Beef Unit included 38,107 individuals. This was 13,023 bulls and 25,084 cows. The current Angus herd had R_{XY} that averaged 0.1274 ± 0.0186 across cows and ranged from 0.0828 to 0.1584. Individual relationship coefficients among herd cows ranged from 0.0555 to 0.5605.

Their F_X averaged 0.0460 ± 0.0249 and ranged from 0.0226 to 0.1619. Individual relationships for the current cow herd and trend of F_X for all ancestors since 1960 are shown in Figure 1. The average relationship coefficient of ancestors born in 1960 onward to the current cow herd are shown in Figure 2.

Table 1. Relationships and ranges of possible fractions of genes in common due to ancestry for a given type of relative when no inbreeding is present.

Type of Relatives	Relationship Coefficient	Range in Actual Relationship
Coefficient Possible		
Parent-offspring	½	No variation
Half-siblings	¼	0 – ½
Full-siblings	½	0 – 1
Grandparent – grandoffspring	¼	0 – ½

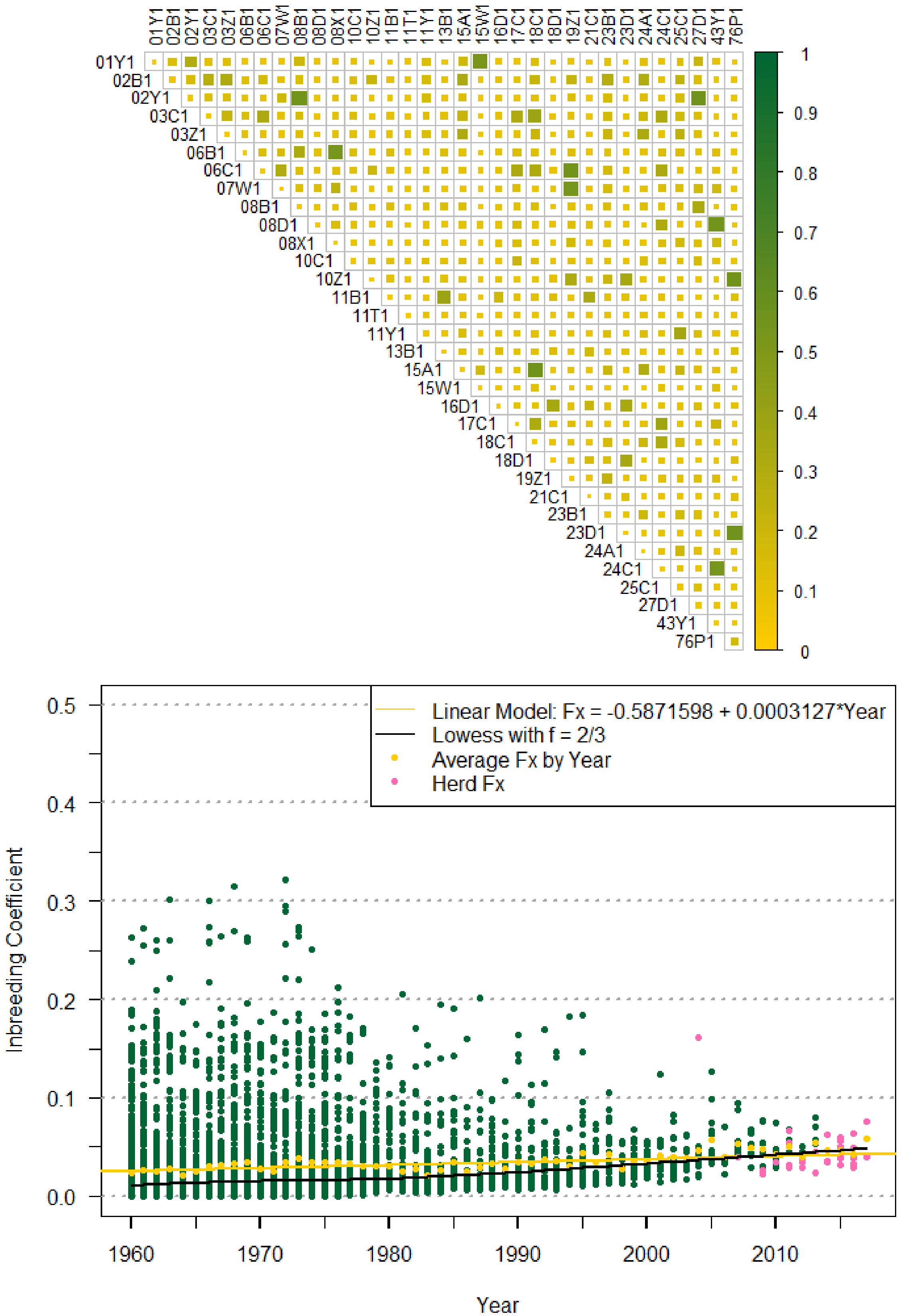

Figure 1. Genetic relationship parameters of current Beef Unit Angus cow herd using tag identification numbers are displayed in the top graph using a correlation matrix. Diagonal elements are individual inbreeding coefficients (ranged from 0.0226 to 0.1619), whereas off-diagonals are relationship coefficients (ranged from 0.0555 to 0.5605) between those two cows. In the lower graph, inbreeding coefficients (F_X) of animals in the Angus cow herd pedigree since 1960 are indicated as individual green dots and current cows are indicated as pink dots. Trends using linear and lowess modeling approaches are displayed.

The number of progeny that an individual in this pedigree had (not including current cows with no progeny in the herd) ranged from one to 96. We had 47 bulls with 30 or more progeny (0.36 percent) in the pedigree and six cows with 10 or more progeny (0.02 percent). Bulls (n = 13) and cows (n = 22) meeting the high count and birth year criteria, along with their average R_{XY} to the current cow herd, are shown in Figure 3.

The average R_{XY} to the cow herd was 0.0758 ± 0.0283 and ranged from 0.0270 to 0.1502. Individual relationship coefficients of current herd cows ranged from 0.0226 to 0.5448 to these key ancestors.

The AAA Pathfinder program was started in the late 1970s as an effort to identify superior cows in the breed. Emphasis for this program is placed on early puberty, breeding and calving, as well as regularity of calving and calf performance. When searching the AAA Pathfinder database, no cows in the current pedigree were listed as an AAA "Pathfinder Dam."

Even so, 42 bulls with Pathfinder-qualifying daughters were present in the current pedigree. These bulls had 0.16 to 14.41 percent of their registered daughters qualifying for the Pathfinder program. The relationship and inbreeding coefficients of these bulls to each other and the average of the current cow herd are shown in Figure 4.

The average R_{XY} to the cow herd was 0.1122 ± 0.0508 and ranged from 0.0743 to 0.1939. Individual relationship coefficients of current herd cows ranged from 0.0252 to 0.5581 to these Pathfinder sires.

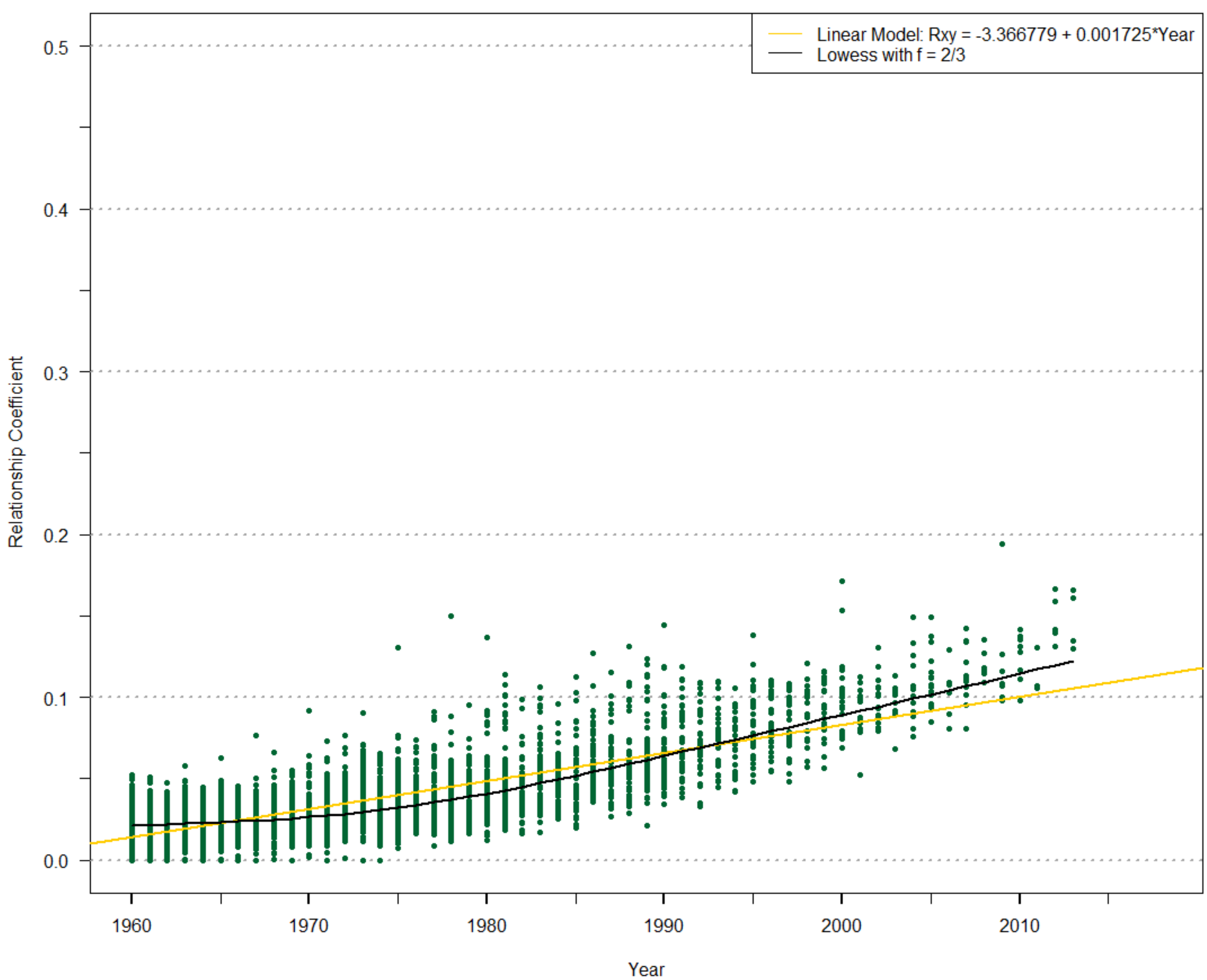

Figure 2. Average relationship coefficients (R_{XY}) of current Beef Unit Angus cow herd to ancestors born since 1960. Trends of genetic relationship are shown using linear and lowess modeling approaches.

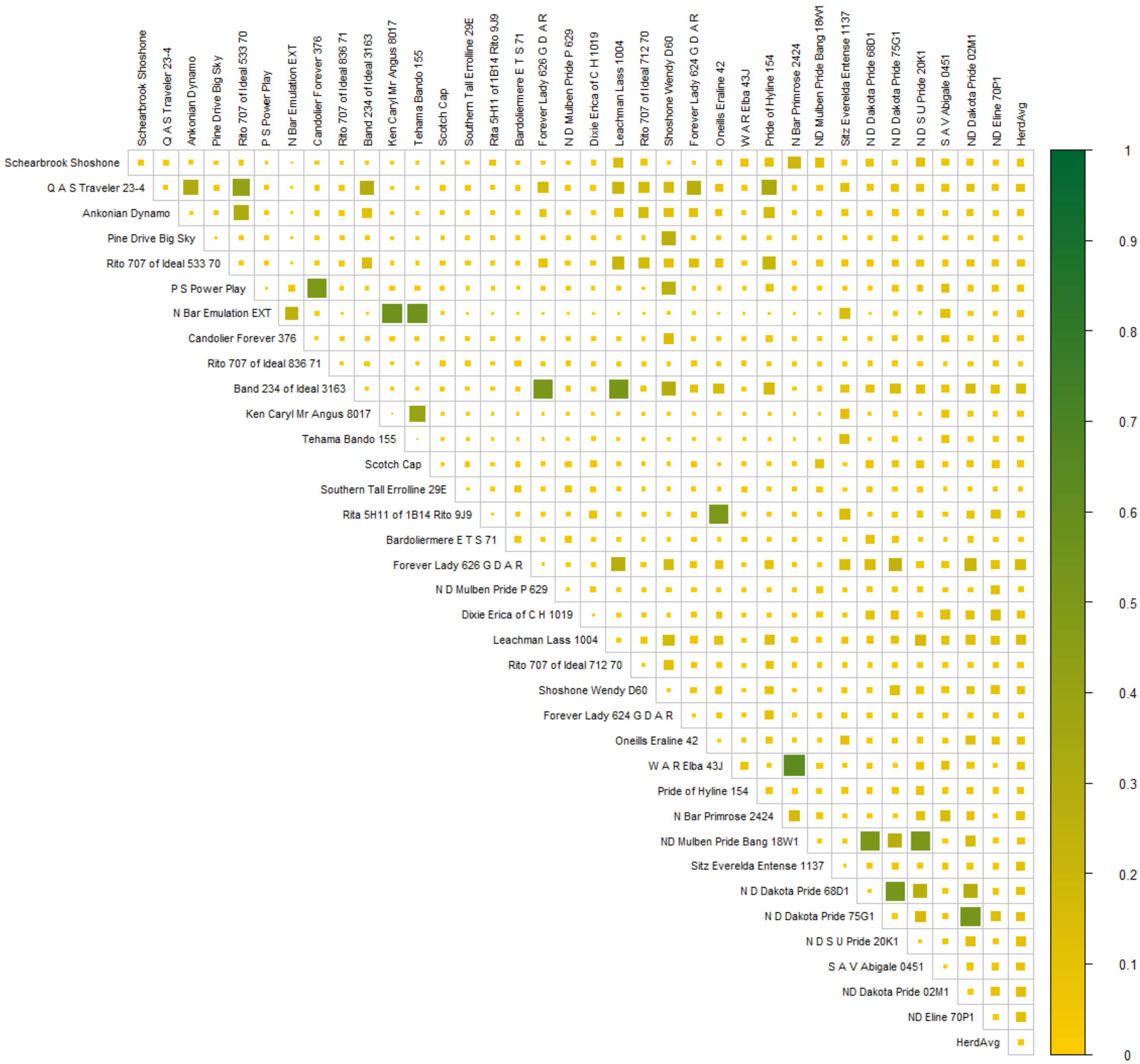

Figure 3. Genetic relationship parameters of ancestors with high counts of progeny (bulls are 15 or more progeny, cows are three or more progeny) born in 1970 or later in the current Beef Unit Angus cow herd pedigree, as well as the average cow herd's relationship to these ancestors, are displayed using a correlation matrix. Ancestor identifications are full registered names. Diagonal elements are individual inbreeding coefficients (ranged from 0.0050 to 0.2566), whereas off-diagonals are relationship coefficients (ranged from 0.0226 to 0.5448) between those two animals.

Simmental Pedigree

Birth years ranged from 1930 to 2016. Similar to the Angus pedigree, birth years prior to 1980 were prone to be incorrect. The Simmental pedigree for the current 43 cows at the Beef Unit included 3,626 individuals.

This pedigree only included individuals that were part (e.g., one-fourth, one-half, three-fourths), purebred or full-blood Simmental. Any ancestor that was a cross or purebred of other breeds was marked as unknown for this study.

The pedigree used included 1,368 bulls and 2,592 cows. The current Simmental herd had R_{XY} that

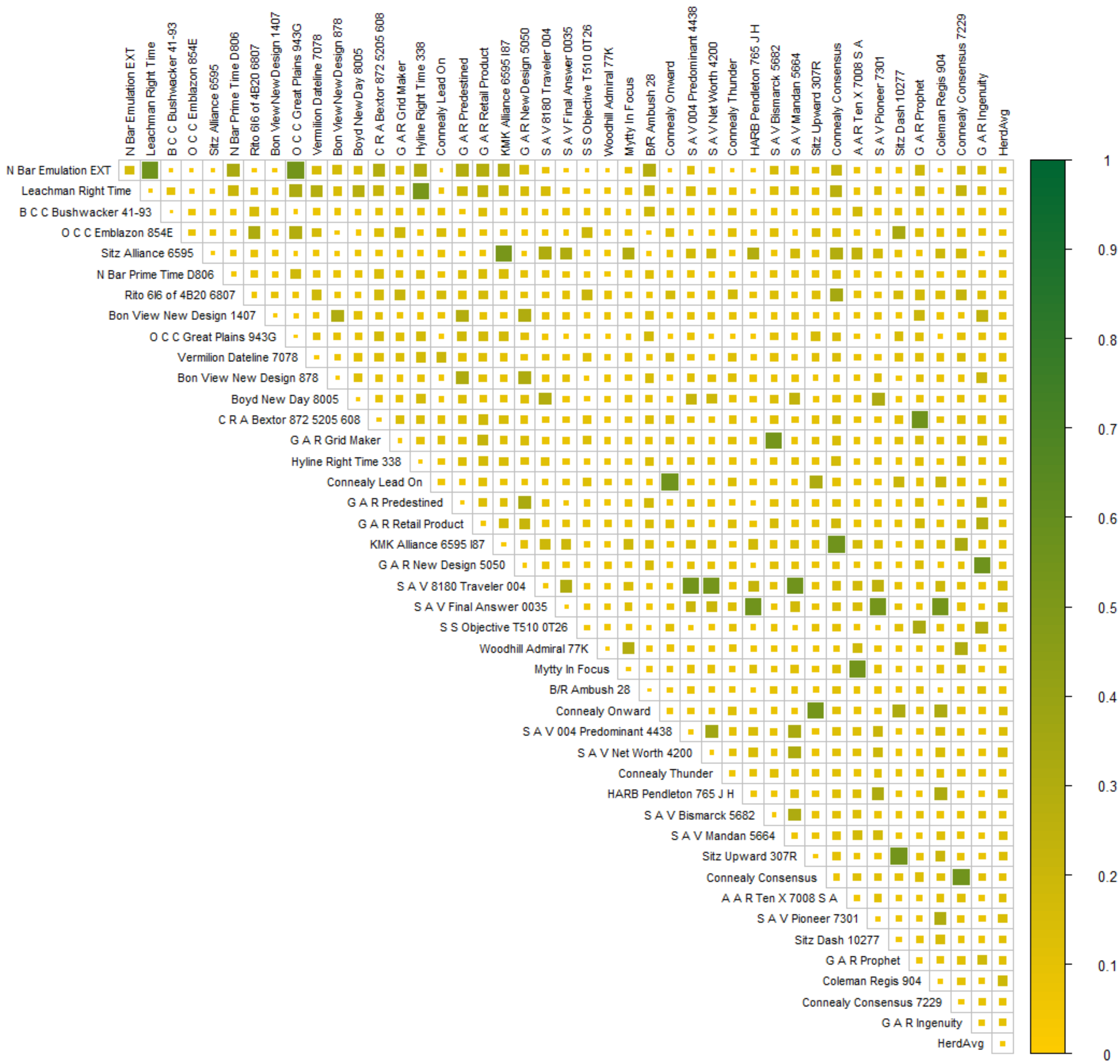

Figure 4. Genetic relationship parameters of American Angus Association Pathfinder sires in the current Beef Unit Angus cow herd pedigree, as well as the average cow herd's relationship to these ancestors, are displayed using a correlation matrix. Ancestor identifications are full registered names. Diagonal elements are individual inbreeding coefficients (ranged from 0.0103 to 0.1603), whereas off-diagonals are relationship coefficients (ranged from 0.0252 to 0.5581) between those two animals.

averaged 0.1345 ± 0.0191 and ranged from 0.0948 to 0.1851. Individual relationship coefficients among herd cows ranged from 0.0507 to 0.5798. Their F_X averaged 0.0473 ± 0.0154 and ranged from 0.0227 to 0.0975.

Individual relationships and the trend of F_X for all ancestors since 1980 are shown in Figure 5. The average relationship coefficient of ancestors born in 1980 onward to the current Simmental herd are shown in Figure 6.

The number of progeny that an individual in this pedigree had (not including current cows with no progeny in the herd) ranged from one to 65. Five bulls had 30 or more

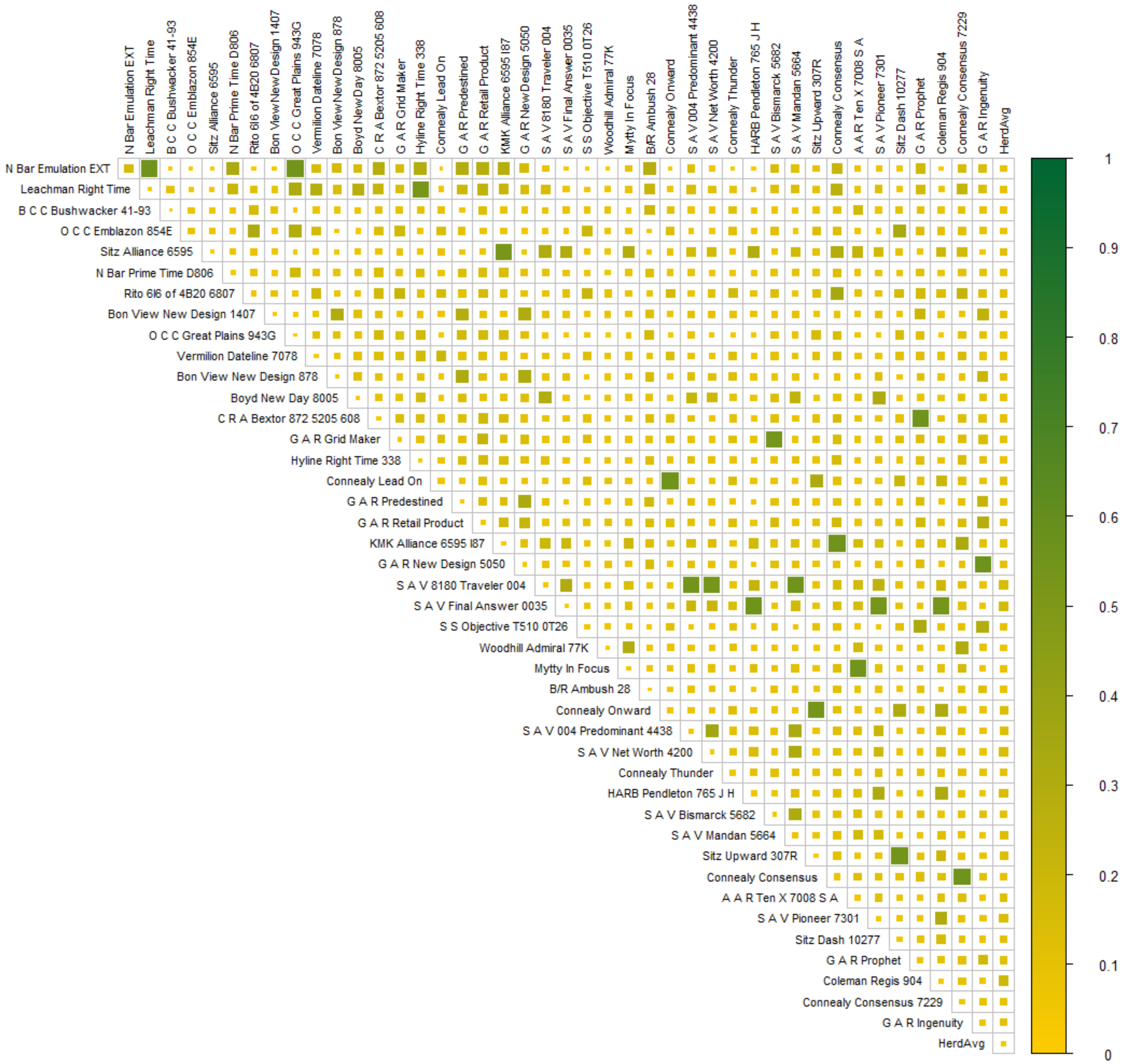

Figure 5. Genetic relationship parameters of current Beef Unit Simmental cow herd using tag identification numbers are displayed in the top graph using a correlation matrix. Diagonal elements are individual inbreeding coefficients (ranged from 0.0227 to 0.0975), whereas off-diagonals are relationship coefficients (ranged from 0.0507 to 0.5798) between those two cows. In the lower graph, inbreeding coefficients (F_X) of animals in the Simmental cow herd pedigree since 1980 are indicated as individual green dots and current cows are indicated as pink dots. Trends using linear and lowess modeling approaches are displayed.

progeny (0.14 percent) and one cow had five or more progeny (0.03 percent).

Bulls (n = 6) and cows (n = 38) meeting the high count and birth year criteria, along with their average R_{XY} to the current cow herd, are shown in Figure 7. The average R_{XY} to the cow herd was 0.0663 ± 0.0237 and ranged from 0.0004 to 0.1612. Individual relationship coefficients of current herd cows ranged from 0 to 0.5546 to these key ancestors.

Based on the ASA database, 10 purebred Simmental bulls overall were ranked in the top 20 for progeny produced from July 1, 2016, to June 30, 2017. The number of progeny produced by these bulls during this time frame ranged from 374 to 1,936 calves.

One of these bulls, WLE Uno Mas X549 (ranked number 10 overall), is present in the current Simmental pedigree as an artificial insemination sire previously used in the Beef Unit's Simmental herd breeding program.

The relationship and inbreeding coefficients of these bulls to each other and the average of the current Beef Unit cow herd are shown in Figure 8. The average R_{XY} to the cow herd was 0.1118 ± 0.0437 and ranged from 0.0923 to 0.1336. Individual relationship coefficients of current herd cows ranged from 0.0496 to 0.5577 to these bulls.

Implications

The Beef Unit's Angus and Simmental females are registered with their respective breed associations. The Angus and Simmental herds are managed in very similar ways genetically. Both herds are bred to maintain each individual herd's

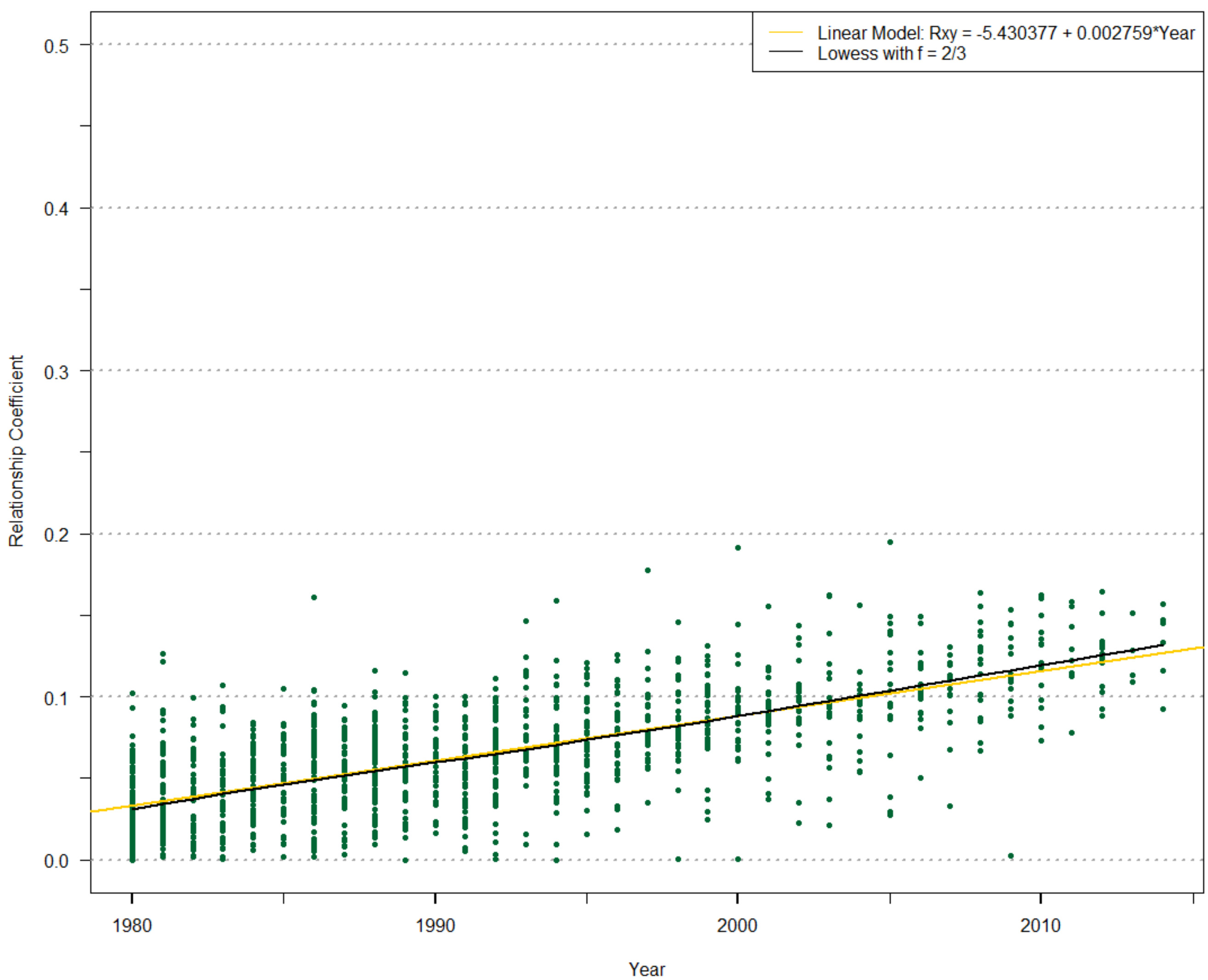

Figure 6. Average relationship coefficients (R_{XY}) of current Beef Unit Simmental cow herd to ancestors born since 1980. Trends of genetic relationship are shown using linear and lowess modeling approaches.

outstanding maternal ability based on breed attributes, while still concentrating on improving the balance between nutritional and reproductive efficiency.

Replacement females are raised every year, and genetic progress is made by utilizing artificial insemination practices with superior bulls. In selecting these sires, we take care to moderate weight traits and milk production so that females produced will maintain consistent body condition, reproduce easily and have longevity.

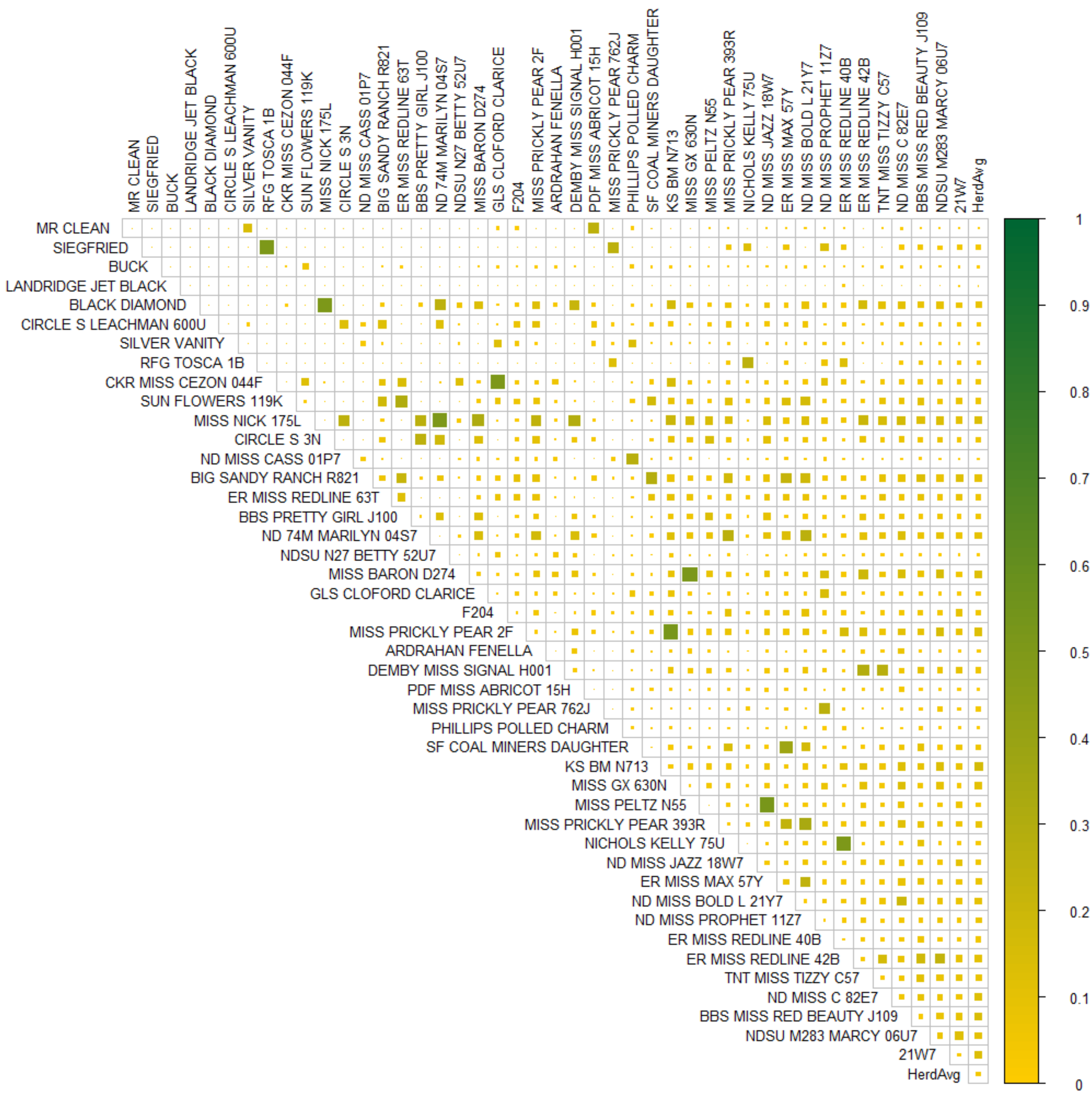

Figure 7. Genetic relationship parameters of ancestors with high counts of progeny (bulls are 15 or more progeny, cows are three or more progeny) born in 1980 or later in the current Beef Unit Simmental cow herd pedigree, as well as the average cow herd's relationship to these ancestors, are displayed using a correlation matrix. Ancestor identifications are full registered names. Diagonal elements are individual inbreeding coefficients (ranged from 0 to 0.1250), whereas off-diagonals are relationship coefficients (ranged from 0 to 0.5546) between those two animals.

While the Angus and Simmental herds' primary breeding goals are to produce replacement females, all calves carry the genetic potential of producing an excellent carcass so that replacement females also can be used in the commercial herd maintained at the Beef Unit. Growth and carcass attributes are capitalized on through hybrid vigor in the commercial herd (an Angus by Angus-Simmental cross breeding system) for production of slaughter calves.

Both herds are maintaining relatively low levels of genetic relationship within each breed, on average. This has assisted with maintaining ideal levels of inbreeding coefficients among herd animals (i.e., F_X less than 0.10) as new sires are rotated into the herds.

The primary exception to this is the Angus cow ND Blackbird 76P1 (F_X = 0.1619), which has parents that are directly sired by the same bull. Even so, she has only two daughters (10Z1 and 23D1) in the current herd. We have taken care to mate her to bulls that are distantly related to reduce progeny inbreeding coefficients.

The same type of relationship coefficients and ranges are seen in both herds relative to key ancestors that have impacted both breed industries. Some are higher because they have been used directly in the Beef Unit's breeding program through the years. These results support that the two herds retain genetic relationships and, therefore, phenotypic similarities, to important breeding animals in each industry while also maintaining genetic diversity.

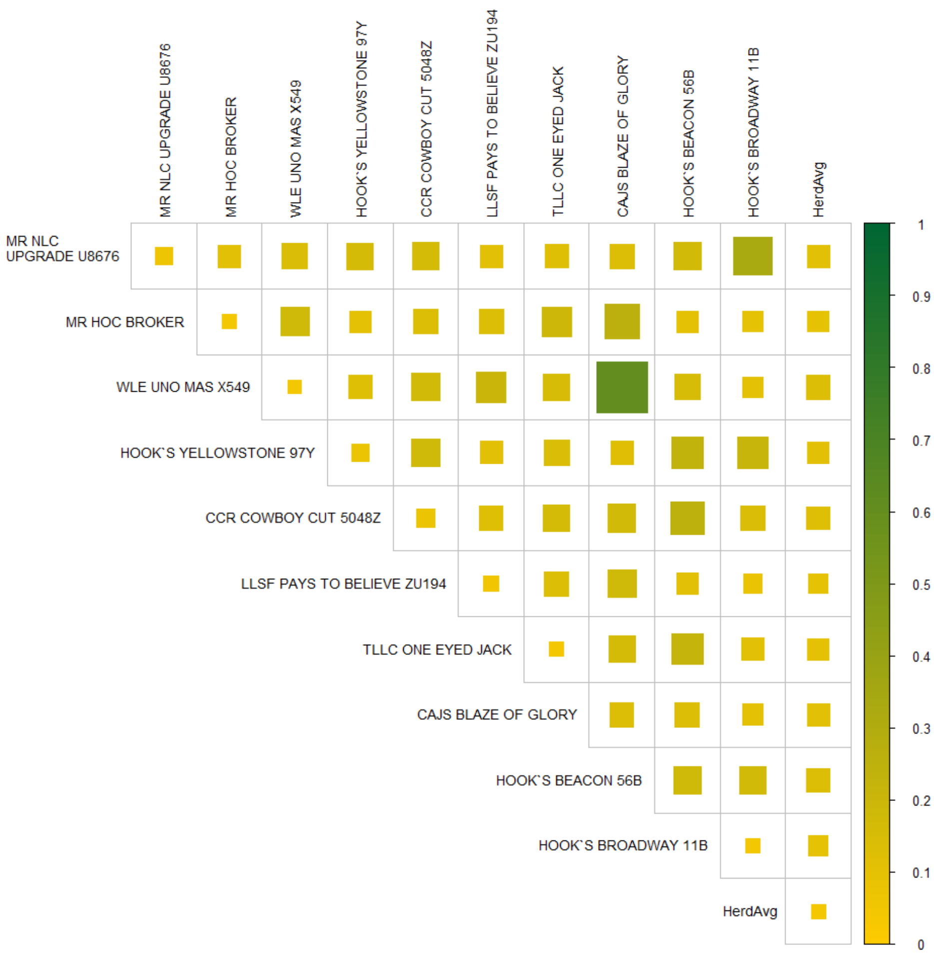

Figure 8. Genetic relationship parameters of purebred Simmental sires listed in the top 20 for progeny counts from July 1, 2016, to June 30, 2017, as well as the average cow herd's relationship to these sires, are displayed using a correlation matrix. Ancestor identifications are full registered names. Diagonal elements are individual inbreeding coefficients (ranged from 0.0412 to 0.1813), whereas off-diagonals are relationship coefficients (ranged from 0.0496 to 0.5577) between those two animals.

Acknowledgments

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Impacts of bale grazing on herbage production, forage quality and soil health in south-central North Dakota

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Study objectives were to determine the impacts of late-season and winter grazing of bales systematically placed on perennial introduced grass hay and pastureland on 1) forage production and nutritional quality, and 2) soil chemical properties. Bale grazing enhanced forage quality one growing season post-treatment, and forage production, soil nitrates, soil phosphorus and soil potassium two growing seasons post-treatment.

Summary

The effect of bale grazing on grass production six months and 18 months after treatment varied, based on ranch site location, by location from 2015 through 2017. The overriding variables that appear to affect grass production are distance between bales and stocking rate intensity (density and duration of time). Grass production was greater on the bale-grazed treatment, compared with the control treatment (no bales on site) 15 feet from the bale center; however, no difference was found within the zone to 10 feet from the bale center six months after treatment. Grass production was greater on the bale-grazed treatment zero, 5 and 10 feet from bale center 18 months after treatment. Bale grazing enhanced grass crude protein and phosphorus content six months after treatment, increasing crude protein out to 10 feet and phosphorus out to 5 feet. Soil nitrates, phosphorus (P) and potassium (K) at the zero to 6-inch soil depth increased on the bale-grazed treatment six months after treatment, with no increase on the control sites. Soil P and K levels remained at elevated levels 18 months post-bale grazing, while soil nitrates declined to pretreatment levels. Organic matter and pH did not change on the bale grazing treatment across years or compared with the control. This rancher demonstration trial showed the increase in urine, feces and hay waste associated with late-season bale grazing on perennial grass-seeded introduced hay and pastureland increased grass production within 15 feet of the bale center in the first six months after treatment or 18 months after treatment, improved forage quality within 10 feet of the bale center six months after treatment, and enhanced soil nutrient parameters within 15 feet of the bale center for nitrates, phosphorus and potassium.

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Introduction

Bale grazing is the practice of allowing livestock access to hay bales in a hayfield or improved pasture to reduce labor and feed delivery costs (Lardner et al., 2008). Livestock producers in the northern Great Plains practicing this technique also are interested in improving soil health and forage production through manure distribution while maintaining adequate livestock performance.

Recently published data have shown a positive relationship between bale grazing and nitrogen capture, as well as forage growth (Jungnitsch et al., 2010; Kelln et al., 2012). However, local producer concerns in our region prompted the need for further applied research.

This project was conducted on four ranches in North Dakota to examine winter hay bale-grazing effects on subsequent years' herbage production and nutritional quality six and 18 months after treatment. Parameters measured included herbage production, nutritional quality, soil nutrient content and cow body condition.

Because bale grazing introduces higher nitrogen and phosphorus into a system, grazing on native pastures is not recommended. Therefore, this project was conducted on improved pastures planted to domesticated cool-season grasses. Herbage production, nutritional quality and soil nutrient content are presented in this report.

Experimental Procedures

Four ranches were selected on different ecological sites — claypan, thin loamy, loamy and shallow

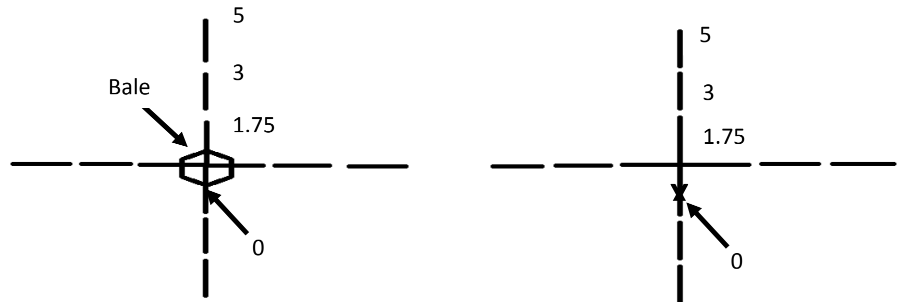

Figure 1. Example of collection locations from bale and control zero, 5, 10 and 15 feet from center for herbage production and soil nutrient content.

Bale-grazed Area			
Bale 1	Bale 2	Bale 3	Bale 4
Adjacent Nonbale-grazed Area – Summer-grazed Only			
X	X	X	X

Figure 2. Example of bale-grazed study area showing a smooth brome grass pasture split into bale-grazing treatment and the parallel nonbale-grazing treatment (control), with "X" representing a corresponding sample location.

gravel — from south-central North Dakota. Sites consisted of improved cool-season grass pastures/hay. Three of the sites had not been bale-grazed.

Four bales of similar hay type were selected randomly per ranch to represent the bale grazing (BG) treatment in September 2015. Bale grazing on all sites occurred from January through March 2016.

Four control sites without bales (C) were selected systematically on the same soil series, slope and plant community directly outside the bale-grazed area and were sampled using the same protocol as the bale-graze sites. See Figures 1 and 2 for project layout design and description.

Herbage was collected during peak production for cool-season grasses in North Dakota and before summer grazing occurred. Vegetation was clipped for biomass in late June or early July at four distance points (bale center and 5, 10 and 15 feet) along each cardinal direction (16 total plots) from the bale center after cattle had grazed the bales on bale-grazed and nonbale-grazed sites in 2016 and 2017 (Figure 1).

Grasses and forbs were separated and composited by plant form from all cardinal directions per bale distance point (four composited samples per bale distance). Hay residue was sampled at the same points and similarly composited to determine waste post-grazing and test for a possible relationship with herbage regrowth and quality.

Herbage samples were weighed, oven-dried at 150 F for 72 hours and reweighed for moisture content. Wet chemistry nutritional analysis on the grass component was conducted at the North Dakota State University Animal Science Nutrition Laboratory. Analysis included crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), ash, calcium (Ca), magnesium (Mg) and phosphorus (P).

Soil samples were collected pretreatment in early October 2015, and six and 18 months post-treatment in 2016 and 2017 at four distance points (zero, 5, 10 and 15 feet) along each cardinal direction (16 total plots) from bale edge (zero feet) after cattle had grazed the bales. Soil cores were collected at zero to 6-inch depths from the same four bale treatment sites and four bale control sites that were used for herbage production. Soil parameters collected included penetrometer (compaction), electrical conductivity, Haney soil health calculation, nitrate, phosphorus, potassium, pH and organic matter.

Results and Discussion

We found no difference ($P > 0.1$) in total grass biomass production among samples from the bale center, and 5 and 10 feet from the bale center on hay/pastureland that was bale-grazed or on similar control hay/pastureland sites six months after treatment. However, bale grazing enhanced ($P \leq 0.1$) grass production 15 feet from the bale center (Table 1).

In contrast to six months after treatment, grass production was greater at the bale center, and 5 and 10 feet from the bale center, compared with 15 feet from the bale center and the control hay/pasture sites 18 months after treatment (Table 1).

Our demonstration trials exhibited that bale grazing increases ($P \leq 0.1$) crude protein content of the grass portion of the vegetation six months after treatment (late June/early July) at the bale center out to 10 feet (Table 2). Grass crude protein content was greater ($P \leq 0.1$) than the control at the bale center, and 5 and 10 feet from the bale but not ($P > 0.1$) at 15 feet from the bale center.

These findings indicate that benefits from bale grazing occur throughout the zone within 10 feet of the bales. This benefit is a result of added nitrogen from urine and fecal material, concentrated within this 10-foot zone.

Grass phosphorus content was not ($P > 0.1$) different among bale treatment distances or control distances (Table 2). However, the bale-grazing treatment increased ($P \leq 0.1$) grass phosphorus content, when compared with the control at the bale center and 5 feet from the bale center six months after treatment (Table 2).

No differences ($P > 0.1$) in neutral detergent fiber (NDF), acid detergent fiber (ADF) or calcium content of the grass component were found between the bale-grazed and control sites six months after treatment (Table 2). Within our demonstration trials, bale grazing had no effect on NDF, ADF or calcium content within the 15-foot zone six months after treatment.

We found no difference ($P > 0.1$) in nitrates (NO_3-N), phosphorus (P), potassium (K), organic matter (OM), pH, electrical conductivity (EC) or Haney health calculation among site locations (distance from bale edge) or control pretreatment at the zero to 6-inch depth in 2015. We founds no difference ($P > 0.1$) in any of these soil parameters among site locations six and 18 months posttreatment in the bale-grazed treatment. Because no differences were found among site location distances from the bale at the zero to 6-inch depth, all distances were combined to represent the bale-grazing treatment.

Nitrates in the soil at depths of zero to 6 inches were greater ($P \leq$ 0.1) on the bale-grazing treatment six and 18 months after treatment, compare with the control. Nitrate levels were 4.4 and 2.6 times greater on the bale-grazing treatment six and 18 months after treatment, respectively (Table 3). The NO3N content declined ($P \leq 0.1$) from six to 18 months after treatment by 70.2 percent.

Phosphorus and K showed similar trends as the NO_3-N, increasing ($P \leq 0.1$) in the soil at depths of zero to 6 inches six and 18 months after treatment, compared with the control (Table 3). However, P and K levels did not decline and were not

Table 1. Grass production at the bale's center and 5, 10 and 15 feet from bale center on winter-grazed bales versus no winter grazing six and 18 months after treatment (collected late June/early July at peak production) in south-central and central North Dakota in 2016 and 2017.

Treatment	Bale center	5 feet from center	10 feet from center	15 feet from center
	lb/a grass in 2016[1]			
Bale grazed	$5,274^{a}$	$5,320^{a}$	$4,613^{a}$	$8,604^{b}$
Control	$5,358^{a}$	$5,823^{a}$	$5,888^{a}$	$6,160^{a}$
	lb/a grass in 2017[1]			
Bale grazed	$3,114^{a}$	$2,611^{a}$	$2,413^{ab}$	$1,848^{b}$
Control	$1,553^{b}$	$1,405^{b}$	$1,383^{b}$	$1,154^{b}$

[1]Grass production by treatment and distances from bale within years with the same letter (a, b) are not different ($P > 0.1$).

Table 2. Grass quality parameters at the bale center, and 5, 10 and 15 feet from the bale center on winter-grazed bales versus no winter grazing in south-central and central North Dakota in 2016 six months after treatment (collected late June/early July at peak production).

Treatment	Bale center	5 feet from center	10 feet from center	15 feet from center
	Crude protein (%) content[1]			
Bale grazed	17.2^{ax}	17.3^{ax}	15.9^{ax}	13.0^{bx}
Control	9.8^{ay}	9.8^{ay}	10.2^{ay}	10.9^{ax}
	Phosphorus (%) content[1]			
Bale grazed	0.30^{ax}	0.30^{ax}	0.27^{ax}	0.27^{ax}
Control	0.23^{ay}	0.23^{ay}	0.22^{ax}	0.24^{ax}
	Calcium (%) content[2]			
Bale grazed	0.48	0.44	0.41	0.38
Control	0.41	0.42	0.39	0.39
	Neutral detergent fiber (%) content[2]			
Bale grazed	61.7	60.9	62.4	64.4
Control	64.2	64.4	63.7	64.1
	Acid detergent fiber (%) content[2]			
Bale grazed	34.2	33.4	33.7	35.2
Control	33.9	34.7	33.7	34.1

[1]Nutritional parameters by treatment and distances from bale with the same letter (a, b) within row (treatment) are not different ($P > 0.1$), and with same letter (x, y) within columns (between treatments) are not different ($P > 0.1$).
[2]No differences ($P > 0.1$) were found among treatments or distances.

Table 3. Soil nutrient parameters on winter bale grazing at soil depths of zero to 6 inches pre- and post-treatment in south-central and central North Dakota in 2015 (pretreatment), 2016 (six months post-treatment) and 2017 (18 months post-treatment).

	NO_3-N (lb/ac)			Phosphorus (ppm)			Potassium (ppm)		
Treatment	2015	2016	2017	2015	2016	2017	2015	2016	2017
Bale grazing	12.8^{ax}	77.3bx	23.0^{ax}	10.1^{ax}	24.5^{bx}	25.2^{bx}	346^{ax}	981^{bx}	890^{bx}
Control (no bale grazing)	29.6^{ax}	18.4^{by}	8.9^{by}	9.7^{ax}	9.9^{by}	12.2^{by}	292^{ax}	409^{by}	252^{by}

[1]Soil nutrient parameters by treatment within the same soil nutrient parameter with the same letter (a, b) within row (treatment) are not different ($P > 0.1$), and with same letter (x, y) within columns (between treatments) are not different ($P > 0.1$).

Table 4. Soil nutrient parameters on winter bale grazing at soil depths of zero to 6 inches pre- and posttreatment in south-central and central North Dakota in 2015 (pretreatment), 2016 (six months post-treatment) and 2017 (18 months post-treatment).

	Organic matter (%)			pH			EC (mmhos/cm)		
Distance from bale edge	2015	2016	2017	2015	2016	2017	2015	2016	2017
Bale grazing	4.0^{ax}	5.2^{ax}	4.0^{ax}	7.6^{ax}	7.0^{ax}	7.2^{ax}	0.33^{ax}	0.43^{bx}	0.30^{ax}
Control (no bale grazing)	4.2^{ax}	4.6^{ax}	3.8^{ax}	7.5^{ax}	6.9^{ax}	6.8^{ax}	0.29^{ax}	0.19^{ay}	0.19^{ay}

[1]Soil nutrient parameters by treatment within the same soil nutrient parameter with the same letter (a, b) within row (treatment) are not different ($P > 0.1$), and with same letter (x, y) within columns (between treatments) are not different ($P > 0.1$).

different ($P > 0.1$) between the six and 18 months after treatment.

We found no differences ($P > 0.1$) among years and treatments in soil OM or pH within the zero to 6-inch soil depth six or 18 months after treatment (Table 4).

Electrical conductivity of the soil increased ($P \leq 0.1$) 30 percent on the bale-grazing treatment six months after treatment; however, it returned ($P > 0.1$) to pretreatment levels 18 months after treatment at soil depths of zero to 6 inches (Table 4). Because the EC level remained low (less than 1 millimho per centimeter [mmho/cm]) in the 2016, this increase would have no adverse effect on forage production.

The Haney soil health calculation was not different among the bale-grazing treatment and control six or 18 months after treatment in soils at depths of zero to 6 inches (Table 5). The Haney soil health calculation appeared to increase for the bale-grazing and control sites, but both declined to pretreatment levels 18 months after treatment for the bale-grazing and control sites. Because the control had a similar positive and negative trend, compared with the bale-grazing treatment, the increase and decrease occurred due to environment or climatic effects and not due to the bale-grazing treatment during our sampling period.

The effects of bale grazing on herbage production varied by ranch location; however, the distance between bales was the variable with the most impact on production. Summer herbage production was greater 15 feet from the bales during the year of the winter bale grazing and greatest from the bale center to 10 feet the second year following winter bale grazing. Residue and manure appeared to be a limiting factor affecting forage production

Table 5. Haney soil health calculation on winter bale grazing at soil depths zero to 6 inches pre- and post-treatment in south-central and central North Dakota in 2015 (pretreatment), 2016 (six months post-treatment) and 2017 (18 months post-treatment).

	Haney soil health calculation (range: 1 to 50+)		
Distance from bale center	2015	2016	2017
Bale grazing	19.4	37.2	18.3
Control (no bale grazing)	20.5	34.6	15.5

where bales were spaced at 15 feet or less.

The open spacing pattern of bales at 40 to 50 feet apart appeared to better distribute cattle and minimize hay residue. Winter bale grazing positively affected crude protein and P content of grass growth during the growing season following the bale-grazing treatment; however, the bale-grazing treatment had no effect on acid detergent fiber, neutral detergent fiber or calcium content.

Bale grazing increased soil NO_3-N, P and K levels, irrelevant of distance from the bale edge, the first growing season after winter bale treatment, and the second growing season after winter bale treatment for P and K. However, soil NO_3-N declined to pretreatment levels during the second growing season.

Bale grazing did not change organic matter and pH or improve the Haney soil health calculation during the first or second growing season following the winter bale-grazing treatment. Although EC increased in the first growing season after the bale-grazing treatment, the EC levels declined to pretreatment levels in the second growing after treatment.

This project has provided insight on the influences of bale grazing on herbage production, forage quality and soil nutrient composition when studying different scales of bale distribution and stocking densities. Bale grazing appears to be a late-season grazing strategy that creates opportunity to increase forage production and quality, enhance some soil nutrients, and reduce labor and fuel costs associated with hauling manure and feeding cattle in a feedlot.

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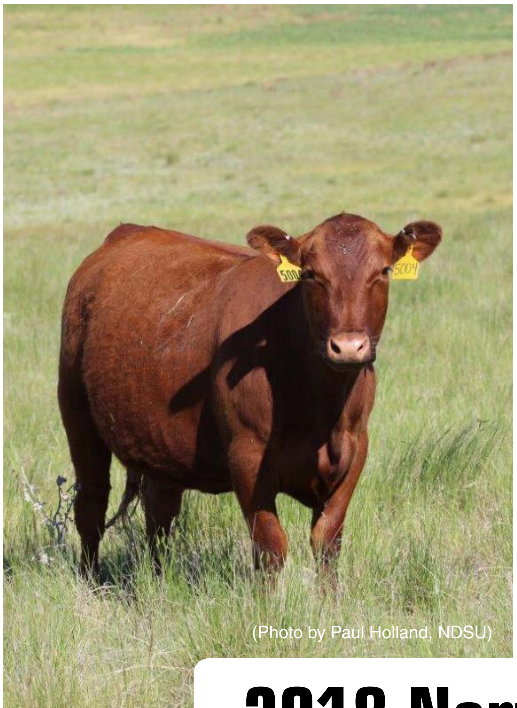

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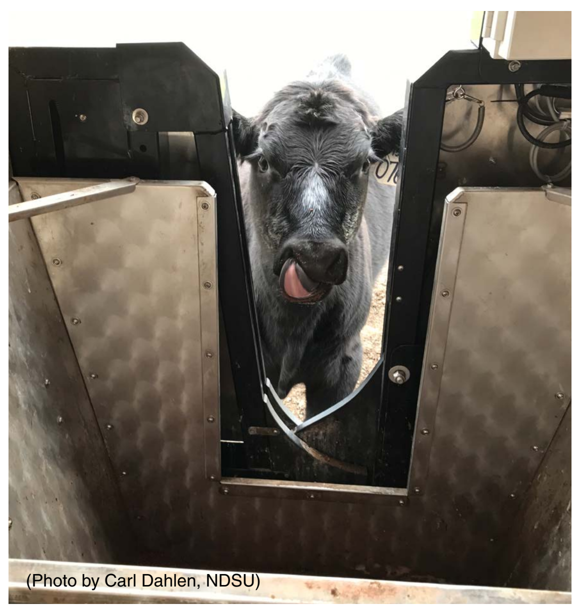

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