Evaluation of terminal-sired calves by artificial insemination or natural service reared in limited resource environments

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INTRODUCTION

To meet the dietary needs of the increasing global population, more efficient agriculture production systems are warranted. The Food and Agriculture Organization estimates food production must increase 70% by 2050 to meet the demand of the increasing population (FAO, 2009). To increase efficiency of beef cattle production, distinct breeding objectives need to be set based on the objectives and resources available to individual firms (Spangler, 2014).

Terminal breeding programs involve selling all steer and heifer calves at weaning with intentions of entering the feedlot. Terminal breeding focuses on early growth rate, calf survival, disease resistance, feed intake, meat quality, carcass composition, and male fertility (Spangler, 2014). Expected progeny differences (EPD) and artificial insemination (AI) are useful tools producers can use to select bulls with desired terminal traits.

AI can be economically advantageous over natural service (NS) breeding programs. Lardner et al. (2015) realized approximately $212.20 greater net profit per cow when comparing fixed-time artificial insemination with an NS breeding.

The opportunity for progeny in a terminal system to reach their maximum preweaning genetic potential for growth may depend on the forage quality and nutrient intake. Pasture in the Nebraska Sandhills is dominated by two forage types, subirrigated meadow (MDW) and upland range (RNG), with separate nutrient profiles. MDW tends to be greater in crude protein and total digestible nutrients compared with range pastures during the grazing period (Lardy et al., 1997). A better understanding how terminal genetics perform in limited resource environments, may help producers select genetics that excel in their production environment. Therefore, the objective of this study was to evaluate postnatal growth and performance of terminal-sired calves using AI or NS on two different grazing systems.

MATERIALS AND METHODS

All animal handling procedures and facilities used in this experiment were approved by the University of Nebraska Animal Care and Use Committee. Cow and calf performance data were collected at the Gudmundsen Sandhills Laboratory (GSL), Whitman.

Dam Management

One hundred twenty-four (5/8 Red Angus, 3/8 Simmental), March-calving cows from the Nebraska Ranch Practicum teaching herd (Springman et al., 2018) were used in this study. Cows were randomly assigned within cow age to be bred to a terminal bull by AI or terminal bulls used for NS. In addition, cows were assigned to graze

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either RNG or MDW from June 1 until weaning in November. Dams remained in their respective treatment for the duration of the study. Treatments were assigned 1 yr prior to data collection. Milk data were collected on a subset of the dams (n = 51) via weigh-suckle-weigh in June, July, September, and November following a protocol adapted from (Williams et al., 1979). Dams were diagnosed for pregnancy on September 5 via transrectal ultrasonography (Aloka; Hitachi Aloka Medical America Inc., Wallingford, CT). Dams were overwintered as a single cohort on MDW pasture and supplemented with meadow hay (7% to 7.5% crude protein). After calving, cows were supplemented with hay and 0.454 kg of dried distillers grain-based supplement (27% crude protein) until May 15.

Dams allotted to AI were synchronized using the 7-d CO-Synch + controlled internal drug release (CIDR) protocol. On d 7, cows received a 2-mL i.m. injection of gonadotropin-releasing hormone (Factrel; 100 µg gonadorelin hydrochloride; Zoetis Animal Health, Parsippany, NJ) and a CIDR (Eazi-Breed CIDR; 1.35 g progesterone; Zoetis Animal Health, Parsippany, NJ). Dams assigned to AI were bred to a Simmental × Angus terminal bull. Cleanup bulls were placed with the AI dams 7 d after AI on June 10 and remained with the cows until July 20. Data from AI dams that did not conceive to AI were removed from the analysis.

Bull placement for the NS breeding treatment coincided with AI on June 3. Terminal bulls (5/8 Red Angus, 3/8 Simmental) remained with the NS dams for a 45-d breeding season. The average bull to cow ratio over the 4 yr of the study was 1:17.

Calf Management

At birth, calves received a 7-way clostridial vaccine (Alpha 7; Boehringer Ingelheim, Duluth, GA). At branding, bull calves were castrated and all calves received vaccinations for infectious bovine rhinotracheitis, bovine viral diarrhea types I and II, bovine parainfluenza virus-3, bovine respiratory syncytial virus, *Mannheimia haemolytica*, and *Pasteurella multocida* (Vista Once SQ, Merck, Kenilworth, NJ); and a 7-way clostridial vaccine (Vision 7; Merck, Kenilworth, NJ). At weaning in November, all calves received two doses of Vista Once SQ 14 d apart and a 7-way clostridial vaccine with somnus (Vision 7 Somnus; Merck, Kenilworth, NJ).

Calf body weight (BW) was measured at birth, May, June, July, September, and at weaning. A common age 205-d weaning weight (WW) was calculated using the formula: ([WW − birth BW]/[weaning date – birth date] × 205). Calves remained at GSL for 2 wk after weaning in a drylot and received ad libitum hay. Calves were then transported (162 km) to the feedlot at the West Central Research and Extension Center (WCREC), North Platte.

Postweaning Calf Management

Calves entered the WCREC feedlot in mid-November as calf-feds. Calves were weighed, received an electronic identification tag, and implanted with 100-mg trenbolone acetate and 14-mg estradiol benzoate (Synovex Choice; Fort Dodge Animal Health, Overland, KS). All calves were adapted over a 21-d period to a common finishing diet consisting of 7% ground prairie hay, 38% wet corn gluten feed, 7% supplement and 48% dry-rolled corn (dry matter basis). Calves were reimplanted approximately 105 d prior to harvest with 200-mg trenbolone acetate and 24-mg estradiol benzoate (Synovex Plus; Fort Dodge Animal Health). An injectable insecticide was also given at this time (Clean-Up II; Bayer Animal Health, Kansas City, MO.). Individual feed intakes were recorded using a GrowSafe feeding system (GrowSafe Systems Ltd., Airdrie, AB, Canada) after a diet adaptation period until 1 d prior to slaughter. Dry matter intakes (DMI), average daily gain (ADG) and gain to feed (G:F) were calculated from the beginning of December to reimplant and from reimplant to the day prior to harvest.

Calves were harvested in mid-June each year (Tyson Fresh Meats, Lexington, NE). Carcass data were collected 24 h following harvest and final BW was calculated from hot carcass weight (HCW), based on an average dressing percentage of 63%. Carcass data included HCW, backfat (BF), calculated yield grade (YG), *longissimus* muscle area (LMA), and marbling.

Statistical Analysis

Data were analyzed using PROC MIXED procedure of SAS (version 9.4; SAS Institute Inc., Cary, NC). Data were analyzed as a 2 × 2 factorial with factors being breeding system (AI or NS) and grazing treatment (RNG or MDW). Individual calf was considered the experimental unit. The model included year and sex as fixed effects and Julian birthdate was considered a covariate ($P < 0.10$). The PROC GLIMMIX procedure of SAS (version 9.4; SAS Institute Inc) was used to evaluate linear regression of calf weight and milk production throughout the grazing period. A P-value < 0.10 was considered significant.

RESULTS AND DISCUSSION

Calf performance during the grazing period for 3 yr of the study is presented in Table 1 and Figure 1. Breeding and grazing treatments did not affect Calf BW at birth, pre-breeding and June ($P \geq 0.10$). Calves grazing RNG weighed less ($P = 0.06$) in July compared with calves grazing MDW. A breeding × grazing treatment interaction was observed ($P \leq 0.05$) in September and at weaning with NS-RNG calves being 16 kg lighter than all other treatments. Grazing treatment influenced ($P < 0.01$) WW per day of age and adjusted 205-d average WW. Thrift and DeRouen (2005) reported differences in 205-d adjusted WW from calves sired by average and high WW EPD bulls. Another study conducted at the same location using maternal trait bulls reported similar calf BW at birth and pre-breeding from dams that grazed MDW after parturition until July 20 (Musgrave et al., 2018); however, numerical differences for calf BW at weaning were 27.4 kg greater, final live weights were 12 kg greater and HCW was 7.5 kg greater in the current

Table 1. Effect of AI or NS breeding and RNG or MDW grazing on postnatal calf growth

	Treatment					*P*-value[1]			
	AI-MDW	AI-RNG	NS-MDW	NS-RNG	SEM	BRD	GRZ	B × G	JDOB
n	24	18	31	30					
Body weight, kg									
Birth	37.6	40.4	37.2	36.7	1.38	0.12	0.41	0.15	—
Pre-breeding	86.6	87.1	86.6	84.4	2.69	0.63	0.71	0.52	<0.01
June	115	114	117	112	3.59	0.10	0.34	0.48	<0.01
July	154	149	160	148	5.35	0.69	0.06	0.44	0.09
September	224[ab]	228[ab]	233[a]	215[b]	7.27	0.84	0.26	0.05	<0.01
Weaning WDA[2], kg/d	1.24	1.21	1.27	1.16	0.03	0.65	<0.01	0.12	—
Weaning	279[a]	272[a]	282[a]	256[b]	6.82	0.30	<0.01	0.09	<0.01
205 d	221	212	225	202	5.44	0.51	<0.01	0.12	—

[ab]Means within a row with dissimilar superscripts are significantly different ($P < 0.10$).

[1]BRD = breeding treatment main effect, GRZ = grazing treatment main effect, B × G = breeding × grazing treatment interaction, JDOB = calf Julian date of birth included in model when significant ($P < 0.10$).

[2]WDA = weight per day of age.

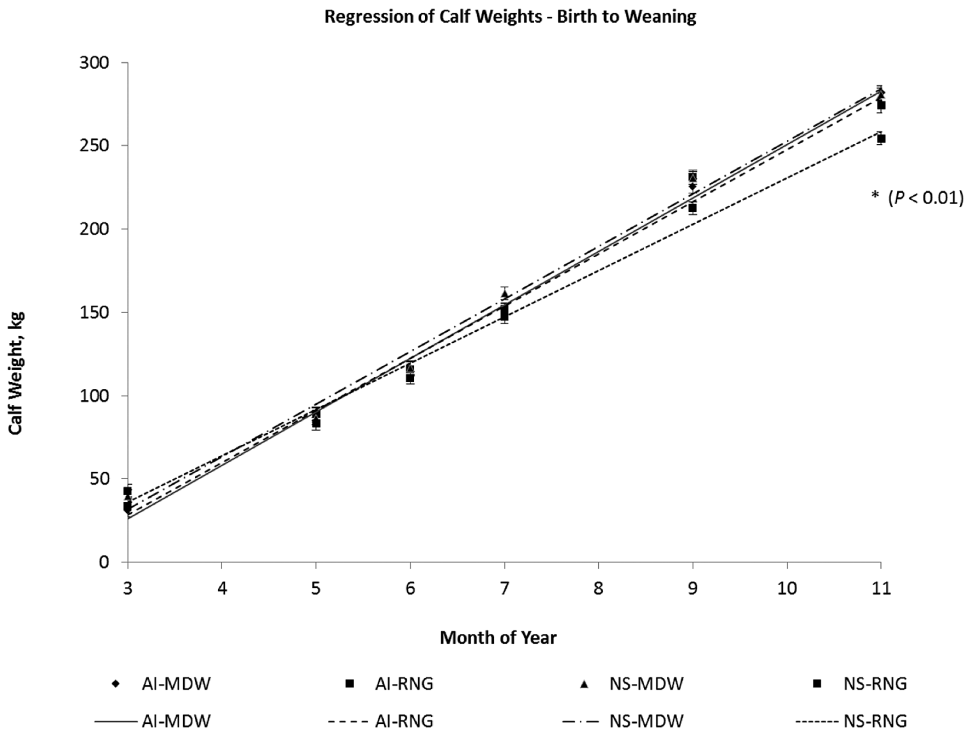

Figure 1. Linear regression of calf body weight (BW) from March birth to November weaning. Calves were born to dams that conceived either by artificial insemination (AI) or natural service (NS). Cow–calf pairs grazed either subirrigated meadow (MDW) or upland range (RNG) from June 1 to weaning. No difference in calf birth BW was observed ($P \geq 0.13$) until weaning (*$P < 0.01$).

study. The difference in WW in the current study could be attributed to the duration of grazing or genetic potential of the sires used in each study.

Calf feedlot performance is reported in Table 2. Three year of data are reported for the initial feeding period. Because the study is ongoing, only 2 yr of data are reported for the last 105 d of the feeding period. Calf BW at feedlot arrival was influenced ($P < 0.01$) by grazing system with RNG calves being lighter than MDW calves. A breeding × grazing treatment interaction was observed ($P = 0.01$) when the calves entered the GrowSafe feeding system as NS-RNG calves weighed 33 kg less than all other treatments. Calves from AI dams had increased ($P \leq 0.04$) ADG and DMI. However, NS calves had increased ($P = 0.01$) G:F ratios. Heavier cattle entering the feedlot have been shown to be less efficient than lighter cattle with comparable genetic potential (Klopfenstein et al., 1999). Improved feed efficiency may be due to NS calves numerically weighing 15 kg less than AI calves at the start of the feeding period.

NS RNG calves were 45 kg lighter ($P < 0.01$) than all other treatments at reimplant. No differences were observed for ADG ($P = 0.10$) or DMI ($P \geq 0.55$) for the last 105 d of the feeding period. However, gain to feed ratios were greatest ($P = 0.08$) for AI-RNG and NS-MDW, least for AI-MDW and intermediate for NS-RNG calves.

Two year of carcass performance is reported in Table 3. LMA was similar ($P \geq 0.14$) for all treatments. A breeding × grazing interaction was observed for final BW, HCW, BF, marbling, and YG

Table 2. Effect of AI or NS breeding and RNG or MDW grazing on feedlot performance of calf-feds[1]

	Treatment					*P*-value[2]			
	AI-MDW	AI-RNG	NS-MDW	NS-RNG	SEM	BRD	GRZ	B × G	JDOB
Initial 78 d of feeding									
n	24	18	32	30					
Arrival BW, kg	272	260	272	242	7.26	0.21	<0.01	0.11	<0.01
Initial BW[3], kg	321[a]	313[a]	324[a]	280[b]	8.64	0.10	<0.01	0.01	0.02
ADG, kg/d	1.92	2.09	1.89	1.89	0.06	0.04	0.12	0.11	-
DMI, kg/d	10.6	10.9	9.71	9.48	0.36	<0.01	0.83	0.36	-
G:F	0.177	0.183	0.193	0.198	0.008	0.01	0.40	0.95	-
Last 105 d of feeding									
n	17	10	24	24					
Reimplant BW, kg	470[a]	476[a]	458[a]	413[b]	10.9	<0.01	0.04	<0.01	-
ADG, kg/d	1.51	1.64	1.63	1.56	0.07	0.69	0.62	0.10	-
DMI, kg/d	10.4	10.4	10.6	10.3	0.36	0.98	0.55	0.66	-
G:F	0.144[b]	0.159[a]	0.156[a]	0.153[ab]	0.006	0.73	0.24	0.08	-

[ab]Means within a row lacking a common superscript differ ($P < 0.10$).

[1]Calves entered feedlot 2 wk after weaning.

[2]BRD = breeding treatment main effect; GRZ = grazing treatment main effect; B × G = breeding × grazing treatment interaction; JDOB = calf Julian date of birth included in model when significant ($P < 0.10$).

[3]Calf weight at the start of finishing diet.

Table 3. Effect of AI or NS breeding and RNG or MDW grazing on carcass performance of calf-feds[1]

	Treatment					*P*-value[2]		
	AI-MDW	AI-RNG	NS-MDW	NS-RNG	SEM	BRD	GRZ	B × G
n	17	10	24	24				
Final BW, kg	623[a]	657[a]	620[a]	572[b]	15.9	<0.01	0.59	<0.01
HCW, kg	393[a]	414[a]	390[a]	360[b]	10.0	<0.01	0.58	<0.01
Backfat, cm	1.52[a]	1.52[a]	1.65[a]	1.14[b]	0.13	0.24	0.02	0.02
Marbling[3]	514[ab]	547[a]	546[a]	478[b]	32.0	0.51	0.51	0.06
USDA yield grade	3.03[a]	3.01[a]	3.02[a]	2.34[b]	0.22	0.07	0.06	0.07
LMA[4], cm[2]	93.4	96.4	95.7	87.7	4.48	0.39	0.51	0.14

[ab]Means within a row lacking a common superscript differ ($P < 0.10$).

[1]Calves entered feedlot 2 wk after weaning.

[2]BRD = breeding treatment main effect; GRZ = grazing treatment main effect; B × G = breeding × grazing treatment interaction.

[3]Marbling:Small[50] = 450, Modest[00] = 500, Modest[50] = 550.

[4]LMA = *Longissimus* muscle area.

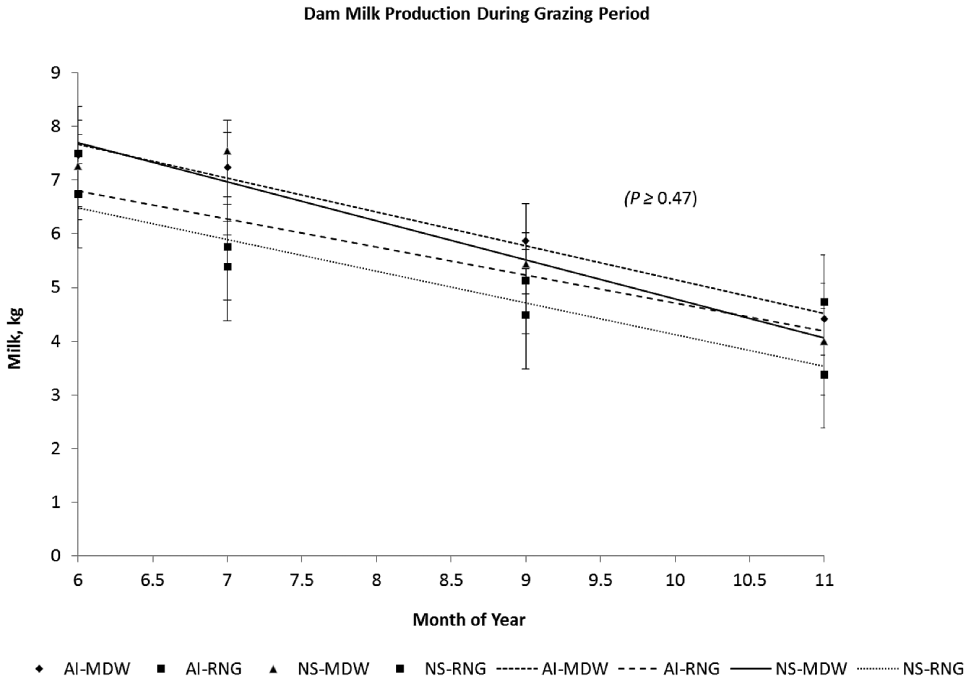

Figure 2. Linear regression of breeding treatment and grazing treatment on dam milk production from June to November. Where (AI) dams bred by artificial insemination, (NS) dams bred by natural service, (MDW) dams grazing subirrigated meadows, (RNG) dams grazing upland range. No differences ($P \geq 0.47$) in breeding or grazing treatment were observed.

($P \leq 0.07$). Final BW and HCW was least ($P \leq 0.01$) for NS-RNG calves (48 ± 15.9 kg BW, 30 ± 10 kg HCW less); all other treatments had similar final BW and HCW. In addition, NS-RNG calves had the least amount of BF and decreased YG scores (0.38 ± 0.13 cm, 0.67 ± 0.07) respectively. Marbling was similar for NS-MDW calves and AI-RNG calves, intermediate for AI-MDW calves, and least for NS-RNG calves. Increased marbling scores were observed by Lansford et al., (2019) for May-born steers grazing MDW pastures at the same location. Because AI-RNG calves in the current study have similar marbling scores to the calves grazing meadow, we suspect the increase in marbling scores is attributable to the AI bull genetics. It is likely additional days on feed are needed for NS-RNG calves to reach their maximum potential HCW, BF, and YG.

Milk production of dams is reported in Figure 2. Linear regression of milk production shows breeding and grazing treatment did not affect milk production throughout the grazing period ($P \geq 0.47$, Figure 2).

Results from this study show synchronization and AI may be an effective way to increase calf growth and performance grazing RNG pastures in the Nebraska Sandhills compared with NS breeding methods. An economic evaluation of the current study upon completion may clarify advantages and disadvantages.

Conflict of interest statement. None declared.

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