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COMPARISON OF CROSSBRED COWS CONTAINING VARIOUS PROPORTIONS OF BRAHMAN IN SPRING OR FALL CALVING SYSTEMS: III. PRODUCTIVITY AS THREE-, FOUR-, AND FIVE-YEAR OLDS[1,2]

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ABSTRACT

Productivity of 3-, 4-, and 5-yr-old crossbred cows containing various proportions (0, 1/4, or 1/2) of Brahman breeding out of Angus or Hereford dams was evaluated using 489 spring-calving and 427 fall-calving records collected over a 4-yr period. Cows were bred to Limousin sires for the first 3 yr and to Limousin and Salers sires the 4th yr. Interactions between crossbred cow group and season of calving were not significant. Percentage of cows exposed to breeding that weaned a calf increased ($P < .01$) as proportion Brahman breeding increased, was higher ($P < .01$) for cows out of Angus dams than for cows out of Hereford dams, and was higher ($P < .01$) for spring-calving cows. As the proportion Brahman increased, the percentage requiring assistance at birth decreased, and cows out of Angus dams required less ($P < .05$) assistance than those out of Hereford dams. Preweaning ADG, adjusted weaning weight, weaning conformation, weaning condition, and adjusted weaning hip height increased as proportion Brahman breeding increased. Spring-born calves gained .12 kg/d faster ($P < .01$) than fall-born calves. However, weight at weaning was similar for the two groups; spring-born calves were weaned at an average age of 205 d, and fall-born calves were weaned at an average age of 240 d. Fall-calving cows were heavier ($P < .05$) than spring-calving cows, and 0 and 1/2 Brahman cows were heavier ($P < .01$) than 1/4 Brahman cows. These data indicate that Brahman-cross dams can be used to improve reproductive rate and increase preweaning growth rate, and thus weaning weight. Based on percentage of cows exposed to breeding that weaned a calf, spring calving was superior to fall calving. Interactions between season of calving and crossbred cow group were not significant for any of the traits examined.

Key Words: Crossbreeding, Productivity, Genotype Environment Interaction, Angus, Brahman, Hereford

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Introduction

Crossbreeding is a management technique widely used by commercial beef producers attempting to improve production efficiency. The desirable consequences of crossbreeding are heterosis, rapid incorporation of desirable genetic material, and combining desirable traits from several breeds into a market animal (Willham, 1970). Successful crossbreeding requires the choice of appropriate breed combinations for the environment and production management system (Koger, 1980). Brahman

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and Brahman crosses have the ability to adapt to the heat and humidity of the Gulf Coast region of the United States, which has led to widespread use of this breed in that region (Franke, 1980). Production capabilities of Brahman-cross cows in the Southeastern and Gulf Coast regions are widely documented (Turner et al., 1968; Turner and McDonald, 1969; Peacock et al., 1971, 1981). Because it is suspected that the optimum proportion of *Bos indicus* breeding in crosses with *Bos taurus* cattle may vary with climate and production environment (Gregory and Cundiff, 1980), research under different conditions should be conducted. Different environments have been shown to have various effects on different breed types due to genotype × environment interactions. Peacock et al. (1971) found significant cow breed group × type of pasture interactions for pregnancy rate. Sellers et al. (1970) reported significant season of birth × breed interactions for preweaning growth.

Different types of cattle may have various levels of performance in different environments; therefore, a long-term study was initiated for the evaluation of the effects of genotype (crossbred cow group), environment (season of calving), and genotype × environment interactions on cow productivity using crossbred cows, with different proportions of Angus, Brahman and Hereford breeding, managed in either spring- or fall-calving systems. The objective of this portion of the study was to determine the effects of crossbred cow group, season of calving, and the interaction between crossbred cow group and season of calving on productivity of 3-, 4-, and 5-yr-old crossbred cows.

Materials and Methods

Angus (A) and Hereford (H) dams were assigned at random to spring- and fall-calving groups and mated to A, H, Brahman (B), 1/2B-1/2A, and 1/2B-1/2H bulls to produce crossbred calves that were 0 B (1/2H-1/2A and 1/2A-1/2H), 1/4B (1/4B-1/4H-1/2A, and 1/4B-1/4A-1/2H) and 1/2 B (1/2B-1/2A and 1/2B-1/2H) over a 3-yr period (1981 to 1983). The mating system, origin of foundation breeding stock, and growth performance of crossbred calves were reported by Bolton et al. (1987a). Postweaning growth, sexual development, and pregnancy rate of heifers were reported by Bolton et al. (1987b). Management and productivity of these cows as 2-yr-olds was reported by McCarter et al. (1990). Milk yield of these cows was reported by McCarter et al. (1991).

Cows were maintained on pasture consisting predominantly of big bluestem (*Andropogon gerardii*), little bluestem (*Schizacharium scoparius*), buffalograss (*Buchloe dactyloides*), sideoats grama (*Bouteloua curtipendula*), silver bluestem (*Bothriochloa saccharoides*), and bermudagrass (*Cynodon dactylon*) at the Southwestern Livestock and Forage Research Laboratory, El Reno, OK for the 1984 through 1986 calf crops. After weaning the 1986 calf crops, cows were moved to Stillwater, OK and maintained on pastures similar in composition to those at the El Reno research station. Spring-calving cows were supplemented from mid-December through mid-April with .8 kg/d of cottonseed meal cubes (41% CP) and were provided access to hay (wheat, oat, or Old World bluestem) based on range and weather conditions while in El Reno. Fall-calving cows were fed 1 kg/d of cottonseed meal cubes and were provided access to hay based on range and weather conditions from December through mid-April. After cows were moved to Stillwater, the same basic feeding regimen was used, with the exception that the hay was bermudagrass or prairie. The number of records available for analysis are presented by crossbred cow group, season of calving, and age of dam in Table 1.

Monthly average minimum and maximum temperatures and precipitation amounts for 1984 through 1987 are presented in Table 2. Average minimum temperatures for the winter months ranged from –7 to 1°C; average maximum temperatures ranged from 5 to 15°C. Average maximum temperatures for the summer months ranged from 30 to 35°C. Yearly rainfall amounts ranged from 78.1 cm in 1984 to 116.7 in 1985; most of the precipitation occurred during the spring and fall seasons.

Cows were exposed to Limousin bulls, in single-sire pastures, for a 75-d breeding season for the 1984 calf crop. For the 1985 and 1986 calf crops, cows were synchronized and bred to Limousin bulls by AI once and then placed 2 wk later in single-sire breeding pastures with Limousin bulls for a total breeding period of 75 d. Calf crops were produced in 1987 by breeding cows to Limousin and Salers bulls artificially twice (if a second insemination was

TABLE 1. NUMBER OF AVAILABLE RECORDS BY CROSSBRED GROUP, SEASON OF CALVING, AND AGE OF DAM

Crossbred cow group[b]	Number of sires[c]	Season of calving and age of dam[a]						Total
		Spring			Fall			
		3	4	5	3	4	5	
H × A	10	24	24	16	23	22	16	125
A × H	7	8	8	7	14	14	9	60
BH × A	10	45	41	37	39	39	21	222
BA × H	11	34	34	26	27	25	13	159
B × A	11	40	39	22	39	37	20	197
B × H	10	31	30	23	27	27	15	153
Total	59	182	176	131	169	164	94	916

[a]Age in years.

[b]Sire breed × dam breed, where H = Hereford, A = Angus, BH = Brahman × Hereford, BA = Brahman × Angus and B = Brahman.

[c]Sires of dams.

required) and then placed in single-sire pastures with Limousin clean-up bulls for a total breeding period of 75 d. The same Limousin bulls were used as clean-up bulls for all years. Cows within each breed group were randomly assigned to sire breed groups and then to sires within the breeds. Spring-calving cows were bred to calve in February, March, and April, and fall-calving cows were bred to calve in September, October, and November.

Condition scores (1 = very thin, 9 = very fat, with 5 = average) and weights were obtained for the cows before breeding and at the time their calves were weaned. Calving difficulty scores were assigned by the herdsman using a scale of 1 to 6 (1 = no difficulty, 2 = little difficulty, 3 = moderate difficulty, 4 = major difficulty, 5 = Caesarian section, and 6 = abnormal presentation). Calving scores of 6 were deleted from the analysis because abnormal presentations do not accurately reflect a cow's ability to calve. A score of 3 or more was considered a difficult birth that required assistance. Birth weights were obtained and male calves were castrated within 24 h of birth. Calves remained with their dams on

TABLE 2. RAINFALL AND AVERAGE MINIMUM AND MAXIMUM DAILY TEMPERATURES BY MONTH FOR 1984 THROUGH 1987

Month	1984			1985			1986			1987		
	Temperature[a]			Temperature			Temperature			Temperature		
	Min	Max	Rain[b]	Min	Max	Rain	Min	Max	Rain	Min	Max	Rain
January	–5	7	.5	–6	5	7.7	–5	13	0	–7	7	6.4
February	1	15	1.8	–4	7	11.7	0	13	2.0	–1	13	13.7
March	2	13	13.0	6	17	12.7	5	19	2.7	3	16	8.6
April	7	19	7.3	11	23	13.6	10	22	14.1	7	24	1.6
May	13	25	6.8	14	27	4.3	14	25	12.8	16	29	17.2
June	20	32	13.5	18	30	16.2	20	30	8.8	19	31	17.5
July	20	34	1.6	20	33	6.2	22	35	4.9	21	32	7.4
August	20	35	2.6	20	33	5.8	19	32	17.9	21	34	5.4
September	16	29	3.0	17	29	15.2	19	28	21.3	15	29	11.2
October	10	22	12.3	9	21	11.7	10	21	16.9	6	23	3.1
November	3	16	5.6	2	14	7.2	1	12	10.7	4	17	6.7
December	0	12	10.1	–7	6	4.5	–1	9	3.7	–3	9	9.7
Average or total	9	21	78.1	8	20	116.7	10	22	115.6	8	22	108.5

[a]Temperature averages given in degrees Celsius.

[b]Total precipitation, given in centimeters.

pasture without access to creep feed. Spring-born and fall-born calves were weaned at an average of 205 and 240 d, respectively. The average weaning date was October 10 for the spring group and June 2 for the fall group. Fall-born calves were weaned at an older age; this is a common practice of Oklahoma producers. Calf weight, hip height, condition score, and conformation scores were determined at weaning. Calf condition scores (1 = very thin to 9 = very fat, with 5 = average) and conformation scores, a measure of muscling, (12 = low Choice, 13 = average Choice, and 14 = high Choice) were determined by averaging scores assigned by a committee consisting of two or three evaluators. Calf weaning weights and hip weights were adjusted to 205 and 240 d of age, respectively, for spring- and fall-born calves.

The full model for the analyses included fixed effects for crossbred cow group, sex of calf, season of calving, year of calving, year of calving, age of dam, sire of calf, prebreeding cow weight and condition score, and the random effect of sire of dam nested within crossbred cow group along with all two-factor interactions. Differences between cow groups were tested using sire component of variance. Least squares means were estimated using reduced models containing appropriate effects ($P < .15$) for each trait.

Comparisons among means were made using appropriate orthogonal contrasts. The five contrasts used to evaluate differences among crossbred cow groups were the linear and quadratic effect of increasing proportion Brahman, the effect of Angus vs Hereford as base breed, and the interactions between increasing proportion Brahman and base breed.

Results and Discussion

Significance levels for crossbred cow group, sire of dam nested within cow group, season of calving, sex of calf, age of dam at calving, sire of calf, and cow group × season of calving interaction are presented in Table 3. Percentage of cows exposed to breeding that weaned a calf was significantly affected by crossbred cow group and season of calving. Crossbreed cow group, sire of dam nested within cow group, sex of calf, and age of dam affected percentage of cows exposed to breeding that weaned a calf. Significant effects of

TABLE 3. SIGNIFICANCE LEVELS FOR MAIN EFFECTS INCLUDED IN PRELIMINARY MODEL AND CROSSBRED COW GROUP × SEASON OF CALVING INTERACTION FOR COW PERFORMANCE TRAITS[a]

	Source (df)							Residual	
Trait	CG[b](5)	SIRE1[c](56)	S[d](1)	Sex(1)	DA[e](2)	CG × S(5)	SIRE2[f](43)	Mean square	df
% Weaned[g]	**	NS	**	NA	NS	NS	NA	.0695	795
% Assisted[h]	**	*	NS	*	**	NS	NS	.0133	666
Birth wt, kg	*	**	**	**	**	NS	NS	18.02	660
Preweaning ADG, kg	**	**	**	**	NS	NS	**	.0068	635
Weaning wt[i], kg	**	**	NS	**	*	NS	**	393.7	635
Weaning conformation	**	**	NS	*	*	NS	*	.467	634
Weaning condition	*	**	**	NS	NS	NS	**	.216	634
Weaning hip height, cm	**	NS	**	*	NS	NS	**	94.45	604
Cow wt[j], kg	*	*	*	NA	**	NS	NA	18,577	795

[a]** = $P < .01$, * = $.01 < P < .05$ + = $.05 < P < .10$, NS = $P > .10$, and NA = not applicable.

[b]CG = crossbred cow group.

[c]SIRE1 = sire of dam nested within crossbred cow group.

[d]S = season of calving.

[e]DA = age of dam at calving.

[f]SIRE2 = sire of calf.

[g]% Weaned = percentage of cows exposed to breeding that weaned a calf.

[h]% Assisted = percentage of cows requiring assistance at birth.

[i]Adjusted to 205-d basis for spring-born calves and to 240-d basis for fall-born calves.

[j]Prebreeding cow weight.

TABLE 4. LEAST SQUARES MEANS AND STANDARD ERRORS FOR COW PERFORMANCE TRAITS AND COW WEIGHT

	Trait[a]								
Effect	% Weaned	% Assisted	Birth wt, kg	Preweaning ADG, kg/d	Adj. Wn. wt, kg	Weaning conformation	Weaning condition	Weaning hip height, cm	Cow wt, kg
Crossbred cow group[b]									
H × A	71.9 ± 3.4	.8 ± 1.3	37.2 ± .7	.82 ± .02	218 ± 5	13.1 ± .1	5.5 ± .1	116 ± 2	498 ± 15
A × H	54.8 ± 4.8	8.8 ± 1.9	37.4 ± .9	.83 ± .02	222 ± 5	13.2 ± .1	5.5 ± .1	118 ± 2	467 ± 21
BH × A	71.6 ± 3.0	1.3 ± 1.1	36.2 ± .6	.89 ± .03	235 ± 6	13.4 ± .1	5.7 ± .1	119 ± 2	445 ± 13
BA × H	65.9 ± 3.3	1.6 ± 1.3	37.0 ± .6	.91 ± .02	238 ± 5	13.5 ± .1	5.7 ± .1	118 ± 2	445 ± 14
B × A	75.7 ± 3.3	.3 ± 1.1	34.7 ± .6	.93 ± .02	241 ± 6	13.3 ± .1	5.6 ± .1	119 ± 2	478 ± 13
B × H	74.8 ± 3.6	.8 ± 1.3	36.3 ± .7	.94 ± .03	245 ± 6	13.6 ± .1	5.8 ± .1	121 ± 2	482 ± 15
Season of calving									
Spring	92.3 ± 2.4	2.1 ± .9	38.0 ± .4	.95 ± .02	232 ± 6	13.3 ± .1	5.7 ± .1	112 ± 2	453 ± 9
Fall	45.9 ± 4.2	2.5 ± .9	34.9 ± .4	.83 ± .02	234 ± 5	13.4 ± .1	5.5 ± .1	125 ± 2	485 ± 9
Age of dam, yr									
3	68.6 ± 8.9	4.0 ± .8	35.4 ± .4	.87 ± .03	226 ± 8	13.3 ± .1	5.7 ± .1	119 ± 4	436 ± 9
4	68.2 ± 2.8	1.4 ± .8	36.9 ± .4	.90 ± .02	236 ± 5	13.5 ± .1	5.7 ± .1	120 ± 2	480 ± 9
5	70.6 ± 8.9	1.4 ± .9	37.1 ± .4	.90 ± .04	237 ± 8	13.3 ± .1	5.5 ± .1	117 ± 4	493 ± 9
Sex of calf									
Heifer		.7 ± .8	34.8 ± .4	.86 ± .02	225 ± 5	13.3 ± .1	5.6 ± .1	118 ± 2	—
Steer		3.8 ± .8	38.1 ± .4	.92 ± .02	241 ± 5	13.4 ± .1	5.6 ± .1	119 ± 2	—

[a]% Weaned = percentage of cows exposed to breeding that weaned a calf, % Assisted = percentage of cows requiring assistance at birth.

[b]Sire breed listed first with H = Hereford, A = Angus, BH = Brahman × Hereford, BA = Brahman × Angus, and B = Brahman.

TABLE 5. SELECTED CONTRASTS OF LEAST SQUARES MEANS FOR COW PERFORMANCE TRAITS AND COW WEIGHT[a]

	Contrast[b]								
Trait	L	Q	B	L × B	Q × B	S	LA	QA	Sex
% Weaned[c]	23.8**	2.1	23.8**	−16.2**	6.6	46.4**	2.0	2.8	—
% Assisted[d]	−8.5**	4.7	−8.8*	7.6	−7.9	−.4	−2.6	2.7	−3.1*
Birth wt, kg	−3.72**	−.84	−2.55	−1.40	−.32	3.04**	1.66*	−1.21	−3.24**
Preweaning ADG, kg	.223**	−.089*	−.038	.002	.010	.121**	.032	−.040	−.060**
Weaning wt[e], kg	46.7**	−20.8*	−11.6	−.1	−.1	−1.9	11.1	−10.3	−16.2**
Weaning conformation	.59**	−.43	−.38	−.22	−.13	−.03	−.08	−.34*	−.16*
Weaning condition	.31*	−.26	−.16	−.19	−.14	.22**	−.16	−.10	−.04
Weaning hip height, cm	6.47**	.55	−2.55	−.23	−4.50	−13.40**	−2.54	−4.09*	−1.49*
Cow wt[f], kg	−5.8	143.8**	25.9	−34.6	26.3	−31.4*	56.8**	−31.6	

[a]** = $P < .01$ and * = $P < .05$.

[b]L = linear effect of increasing proportion Brahman, Q = quadratic effect of increasing proportion Brahman, B = effect of base cow breed, L × B = interaction of linear increase in Brahman breeding and base cow breed, LA = linear effect of age of dam, and QA = quadratic effect of age of dam.

[c]Percentage of cows exposed to breeding that weaned a calf.

[d]Percentage of cows requiring assistance at calving.

[e]Adjusted to 205-d basis for spring-born calves and to 240-d basis for fall-born calves.

[f]Prebreeding cow weight.

crossbred cow group, sire of dam, season, and age of dam were found for birth weight. Preweaning ADG and all weaning traits, weight, conformation, condition, and height, were affected by crossbred cow group and sire of calf. Sire of dam affected preweaning ADG and all weaning traits with the exception of height. Sex of calf affected preweaning ADG and all weaning traits with the exception of condition. Preweaning ADG and weaning condition and height were affected by season of calving. Dam age effects were found for weaning weight and conformation. Cow weight was affected by crossbred cow group, sire of dam, season of calving, and age of dam. No cow group × sire of calf interactions were found, and no interactions were found between cow group and breed of sire for the 1 yr that two sire breeds were used. No traits were affected by cow group × season of calving interaction. Birth weight was also affected by condition score of dam at breeding. Prebreeding cow weight and condition score were not significant for any other production traits examined and, therefore, were not included in reduced models for these traits.

Least squares means among with their standard errors and orthogonal contrasts of least squares means for cow performance traits and cow weight are presented in Tables 4 and 5, respectively. Overall, 87.1% of cows exposed to breeding weaned a calf. Bailey et al. (1988) reported similar percentages for B × H and B × A cows, 88 and 82%, respectively, whereas Peacock et al. (1971) reported an average of 71% for cows containing 0, 25, 50, 75, or 100% of B breeding, with the remaining proportion being Shorthorn. In this study, as the proportion of B breeding increased the percentage of cows exposed to breeding increased: 63.4, 68.8, and 75.3%, respectively, for 0, 1/4 and 1/2 B groups. Peacock et al. (1971) found no significant differences between 25, 50, and 75% B dams for pregnancy rate. Bailey et al. (1988) reported similar findings; percentages of 84, 88, and 82% were found for A × H, B × H, and B × A dams, respectively. In this study, a higher percentage of cows out of A dams weaned a calf than did cows out of H dams. Gaines et al. (1966) and Wiltbank et al. (1967) found no differences in A-H reciprocal crosses and Shorthorn × A and Shorthorn × H crosses. Turner et al. (1968) likewise found no differences among 1/2 A and 1/2 H dams sired by B, H, A, and Brangus. In this study, the percentage of cows exposed to breeding that weaned a calf was significantly affected by the interaction of linear increase in proportion B and base cow breed. As the proportion of B increased, the difference between cows out of A dams and H dams decreased. Spring-calving cows weaned higher percentages ($P < .01$) than fall-calving cows. The trend for percentage of cows exposed to breeding that weaned a calf to increase as proportion B increased is different from the trend found for these same cows as 2-yr-olds (McCarter et al., 1990), thus indicating a shift in performance as the cows mature in favor of the F_1 B-cross dams.

The percentage of cows requiring assistance at birth (those receiving a score of 3, 4, or 5) decreased as the proportion of B increased (Table 5). Cows out of A dams required less assistance than those out of H dams. Cows giving birth to male calves required more assistance than those giving birth to female calves. For the entire herd, average percentage assisted was .8%. As for percentage assisted, birth weight decreased as the proportion of B increased. However, no base breed effect was found for birth weight. Weights of spring-born calves were 3.0 kg greater ($P < .01$) than weights of fall-born calves at birth. Roberson et al. (1986) reported similar birth weights for calves born in January through March and October through December, 32.5 and 32.1 kg, respectively. Male calves were heavier ($P < .01$) at birth than female calves by 3.2 kg. As condition score of the cow at breeding increased, birth weight increased. Calves out of cows receiving a score of 4 averaged 35.6 kg, whereas those from cows receiving a score of 7 average 37.2 kg. Birth weights increased ($P < .05$) as age of dam increased.

Preweaning ADG and adjusted weaning weight increased ($P < .01$) as proportion of B increased (Table 5). Similar results were found for these same cows as 2-yr-olds (McCarter et al., 1990). These results also agree with those of Turner and McDonald (1969). The trend for preweaning growth to increase as proportion Brahman increased is similar to that reported by Koger et al. (1975) in calves out of Shorthorn, 1/4 Brahman:3/4 Shorthorn, and F_1 B-Shorthorn dams. Bailey et al. (1988) found progeny of B × A and B × H to be lighter ($P < .01$) at weaning than progeny from A × H dams. Spring-born calves outgained fall-born calves by .121 kg/d; however, because of the difference in age at weaning of the two groups, weaning weight was similar for spring- and fall-born calves. Steers outgained heifers by .06 kg/d, resulting in a 16.2 kg advantage at weaning.

Weaning conformation grades and weaning condition scores increased as proportion of B increased (Table 5). Thus, degree of muscling and condition at weaning increased as proportion of B increased. Seasonal differences in weaning condition scores were significant: spring-born calves received higher scores than fall-born calves. Overall, weaning conformation grades averaged 13.3, and weaning condition scores averaged 5.6.

Adjusted weaning hip height increased as the proportion of B increased. Fall-born calves averaged 13.4 cm taller at weaning than spring-born calves. This difference can be attributed to the fact that fall calves were an average of 35 d older at weaning than spring calves. Steer calves averaged 1.5 cm taller at weaning than did heifer calves.

The quadratic effect of increasing proportion of B significantly affected cow weight (Table 5). Cows with 1/4 B breeding were lighter (445 kg) than those with 0 (483 kg) and 1/2 B (480 kg) breeding. Spring-calving cows were 31.4 kg lighter ($P < .05$) and carried less condition, 4.7 and 5.8 respectively, at breeding than fall-calving cows. This is a reversal of the trend found for these cows as 2-yr-olds. This reversal can be attributed to the lower reproductive performance of the fall-calving cows as 2-yr-olds, which resulted in more energy being available for cow growth. As would be expected, cow weight increased ($P < .01$) with age. Three-year-old dams were 44.5 kg lighter than 4-yr-old dams, which were 20.9 kg lighter than 5-yr-old dams.

Implications

Success or failure of a crossbreeding program depends on the choice of breeds used in the program. Results presented in this study indicate that Brahman-cross dams can be used effectively in a commercial crossbreeding system to increase reproductive rate and preweaning growth rate, and thus weaning weight, compared with *Bos taurus*-cross dams. Differences attributable to season of calving indicate a slight advantage for spring calving relative to fall calving based on reproductive rates and preweaning growth rates. Under the environmental conditions of this study, we determined that crossbred cow groups performed similarly in spring and fall calving systems, because no genotype × environment interactions were found.

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