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COMPARISON OF CROSSBRED COWS CONTAINING VARIOUS PROPORTIONS OF BRAHMAN IN SPRING OR FALL CALVING SYSTEMS: I. PRODUCTIVITY AS TWO-YEAR-OLDS[1,2]

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ABSTRACT

Productivity of 2-yr-old crossbred cows containing various proportions (0, 1/4 or 1/2) of Brahman breeding was evaluated using 203 spring-calving and 171 fall-calving heifers over a 3-yr period. All heifers were mated to Limousin sires. Percentage of cows exposed to breeding that weaned a calf was the only trait for which a significant crossbred cow group × season of calving interaction was found. Preweaning ADG and age-adjusted weaning weight increased as proportion Brahman breeding increased. Age-adjusted weaning weight was similar for the two groups because 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. For weaning condition scores, an interaction between dam breed and proportion Brahman was detected; scores tended to be greater for calves out of 1/2 Hereford dams than for those out of 1/2 Angus dams, and this difference increased as proportion Brahman increased. Weaning conformation scores were similar for all calves. Age-adjusted weaning hip height increased as proportion Brahman breeding increased. Based on numbers of weaned calves, spring calving was more advantageous than fall calving. Averaged across both calving seasons, weaning weight tended to increase as proportion Brahman increased.
(Key Words: Crossbreeding, Genotype Environment Interaction, Reproductive Performance, Angus, Brahman, Hereford.)

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Introduction

Crossbreeding is one of the major management techniques available for commercial beef cattle producers attempting to increase efficiency of production. Additive and nonadditive genetic variation both are important, thus, improvement is maximized by combining systematic crossbreeding with selection among and within breeds (Cundiff, 1970). However, successful crossbreeding requires the choice of appropriate breed combinations for the environment and production management system (Koger, 1980). Different environments have been shown to affect genotypes differently. Peacock et al. (1971) found significant cow breed group × type of pasture interactions for pregnancy rate among purebred Shorthorn, purebred Brahman, 1/4 Brahman-3/4 Shorthorn, 1/2 Brahman-1/2 Shorthorn and 3/4 Brahman-1/4 Shorthorn cows. On improved pasture, pregnancy rate of crossbred cows was increased 19% versus 11% for purebred cows. Sellers et al. (1970) reported a significant season of birth × breed interaction. Spring- and summer-born Angus calves gained faster to weaning than Hereford calves born in these seasons; fall- and winter-born Hereford calves had higher preweaning gains than Angus calves born in these seasons.

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Because different genetic types of cattle may have different levels of performance in different environments, a long-term study was initiated to evaluate 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 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 to weaning of their first calf for 2-yr-old females.

Materials and Methods

Angus (A) and Hereford (**H**) dams were assigned at random to spring- and fall-calving groups and mated to either A, H, Brahman (**B**), B·A or B·H bulls to produce crossbred calves that were 0 B (H·A and A·H), 1/4 B ($B_1H_1A_2$ and $B_1A_1H_2$) and 1/2 B (B·A and B·H) over a 3-yr period (1981 to 1983). Numbers of sires used to produce crossbred heifers for this project are presented in Table 1. 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).

Heifer calves after weaning remained at the Southwestern Livestock and Forage Research Laboratory, El Reno, Oklahoma and were managed to calve first at 24 mo. Spring-born heifers always calved in the spring and fall-born heifers always calved in the fall. Heifers were maintained on pastures 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*). Heifers in the spring group were supplemented from mid-December through mid-April with approximately .8 $kg \cdot hd^{-1} \cdot d^{-1}$ of 41% cottonseed meal cubes and were provided access to hay (wheat, oat and Old World bluestem) based on range and weather conditions. Fall-calving heifers were supplemented with 1 $kg \cdot hd^{-1} \cdot d^{-1}$ of 41% cottonseed meal cubes from December through mid-April and also were provided hay based on range and weather conditions. The number of available heifers is presented by crossbred cow group, season of calving and year in Table 1.

Monthly average minimum and maximum temperatures and precipitation amounts for 1983 through 1986 are presented in Table 2. December and January typically were the coldest months, with average minimum temperatures ranging from –9 to 0°C and average maximum temperatures ranging from 0 to 13°C. July and August were the warmest months, with average maximum temperatures between 32 and 37°C. Yearly precipitation ranged from 78.1 cm in 1984 to 116.7 cm in 1985.

Heifers all were exposed to Limousin sires, in single sire pastures, for a 75-d breeding season for 1983 and 1984 calf crops. Four sires were used to produce 1983 calves and six were used to produce 1984 calves. Sires were obtained from local breeders without having to

TABLE 1. NUMBER OF AVAILABLE RECORDS AND SIRES BY CROSSBRED GROUP, SEASON AND YEAR

Crossbred cow group[a]	Sires	Year and season 1983 Spring	1983 Fall	1984 Spring	1984 Fall	1985 Spring	1985 Fall	Total
H·A	10	10	12	9	6	7	5	49
A·H	6	6	7	6	7	0	0	26
$B_1H_1A_2$	9	21	16	18	11	9	13	88
$B_1A_1H_2$	10	16	14	12	8	10	6	66
B·A	10	13	17	13	10	16	11	80
B·H	9	10	13	20	10	7	5	65
Total	54	76	79	78	52	49	40	374

[a]H·A = Hereford × Angus, A·H = Angus × Hereford, $B_1H_1A_2$ = Brahman-Hereford × Angus, $B_1H_1H_2$ = Brahman Angus × Hereford, B·A = Brahman × Angus and B·H = Brahman × Hereford; sire breed is listed first.

meet any specific selection criteria. For the 1985 calf crop, heifers were synchronized and bred once to one of four Limousin sires by artificial insemination. Ten days to two weeks later, heifers were placed in single-sire pastures with one of four Limousin sires for a total breeding period of 75 d. Spring-calving heifers were bred to calve in February, March and April; fall-calving heifers were bred to calve in September, October and November.

Condition scores and weights were obtained on the heifers before breeding and at the time their calves were weaned. Calving difficulty scores were assigned using a scale of 1 to 6 (1 = no difficulty, 2 = little difficulty, 3 = moderate difficulty, 4 = major difficulty, 5 = caesarean section and 6 = abnormal presentation). Cows receiving a score of 1 or 2 were assigned a value of 0, whereas a score of 3, 4 or 5 was considered a difficult birth that required assistance and was assigned a value of 1 for analysis. Two cows received a score of 6 and were deleted from the calving difficulty analysis because abnormal presentations do not allow accurate evaluation of a cow's ability to calve. Birth weights were obtained and male calves were castrated within 24 h of birth. Calves remained with their dams on pasture without access to creep feed. Spring-born and fall-born calves were weaned at an average of 205 and 240 d, respectively. 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 score were determined at weaning. Calf condition scores (1 = very thin to 9 = very fat, with 5 = average) and conformation scores, a visual appraisal of muscling (12 = Low Choice, 13 = Average Choice and 14 = High Choice), were determined by averaging scores assigned by two to four evaluators. Calf weaning weights and hip heights were adjusted to 205 and 240 d of age, respectively, for spring- and fall-born calves.

Data were analyzed using Harvey's LSM-LMW PC-1 Version (Harvey, 1987). The full model used in the analysis of percentage of cows exposed to breeding that weaned a calf included effects for crossbred cow group, sire of dam nested within cow group, season of calving and year of calving along with two-factor interactions. Prebreeding cow weight and condition score were included as covariates. Birth traits were evaluated using similar models with effects for sire of calf and sex of calf added. Preliminary models for analysis of growth and weaning traits were similar to those used to evaluate birth traits with the addition of cow weight and condition score at weaning as covariates. Differences between cow groups were tested using sire nested within cow group. Least squares means were estimated using reduced models for each of the traits analyzed that contained appropriate ef-

TABLE 2. RAINFALL AND AVERAGE MINIMUM AND MAXIMUM DAILY TEMPERATURES BY MONTH FOR 1983 THROUGH 1986.

	1983			1984			1985			1986		
	Temperature[a]			Temperature			Temperature			Temperature		
Month	Min	Max	Rain[b]	Min	Max	Rain	Min	Max	Rain	Min	Max	Rain
January	−3	7	.8	−5	7	.5	−6	5	7.7	−5	13	0.0
February	0	9	7.7	1	15	1.8	−4	7	11.7	0	13	2.0
March	2	14	7.8	2	13	13.0	6	17	12.7	5	19	2.7
April	5	17	4.1	7	19	7.3	11	23	13.6	10	22	14.1
May	12	24	18.9	13	25	6.8	14	27	4.3	14	25	12.8
June	17	29	9.3	20	32	13.5	18	30	16.2	20	30	8.8
July	21	35	0.0	20	34	1.6	20	33	6.2	22	35	4.9
August	22	37	2.2	20	35	2.6	20	33	5.8	19	32	17.9
September	16	31	5.2	16	29	3.0	17	29	15.2	19	28	21.3
October	11	23	19.3	10	22	12.3	9	21	11.7	10	21	16.9
November	5	16	5.5	3	16	5.6	2	14	7.2	1	12	10.7
December	−9	0	1.0	0	12	10.1	−7	6	4.5	−1	9	3.7
Average or total	8	20	81.8	9	21	78.1	8	20	116.7	10	22	115.6

[a]Temperature averages, given in °C.

[b]Total precipitation, given in cm.

TABLE 3. ANALYSES OF VARIANCE[a]

Trait	Source (df)					Error	
	CG[b](5)	SIRE[c](55)	S[d](1)	Sex (1)	CG × S (5)	Mean square	df
% Weaned[e]	**	*	**	NA	t	.13	253
% Assisted[f]	**	NS	NS	**	NS	.16	188
Birth weight	NS	**	*	**	NS	77.3	182
Preweaning ADG	**	NS	*	**	NS	.03	171
Weaning weight[g]	**	NS	NS	*	NS	1,820	171
Weaning conformation	NS	*	NS	NS	NS	.33	171
Weaning condition	NS	NS	NS	NS	NS	.27	171
Weaning hip height[g]	**	NS	**	NS	NS	195	169
Cow weight[h]	*	**	t	NA	NS	3,864	303

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

[b]CG = Crossbred cow group.

[c]SIRE = Sire of dam nested within crossbred cow group.

[d]S = Season.

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

[f]Percentage of cows requiring assistance at birth.

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

[h]Prebreeding cow weight.

fects ($P < .15$). 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 versus Hereford as base breed and the interactions between increasing proportion Brahman and base breed. Contrasts evaluating possible genotype × environment interactions were used only when preliminary analysis results indicated that interactions were present.

Results and Discussion

Significance levels for crossbred cow group (**CG**), sire nested within CG (**SIRE**), season of calving (**S**), sex of calf (**SX**), and the CG × S interaction are presented in Table 3. Crossbred cow group was a significant source of variation for percentage of cows exposed to breeding that weaned a calf (**%W**), percentage of cows requiring assistance at birth (**%A**), preweaning average daily gain (**ADG**), age-adjusted weaning weight (**WW**), age-adjusted weaning hip height (**WH**) and prebreeding cow weight (**CW**). Season of calving significantly affected %W, birth weight (**BW**), ADG, WH and CW. Sex of calf had a significant effect on %A, BW, ADG and WW. Percentage of cows exposed to breeding that weaned a calf was the only trait for which a significant CG × S interaction existed. Sire of calf and year were not significant for any of the traits evaluated.

Linear contrasts of least squares means for %W are presented in Table 4. Differences in %W were due primarily to differences in pregnancy rate; total cow productivity is reflected more clearly by %W than pregnancy rate. Preliminary analyses indicated the CG ×

TABLE 4. LINEAR CONTRASTS OF LEAST SQUARES MEANS FOR PERCENTAGE OF COWS EXPOSED TO BREEDING THAT WEANED A CALF USING CROSSBRED GROUP BY SEASON OF CALVING MEANS

Comparison	Contrast	SE
Linear effect of increasing proportion Brahman	−43.0**[a]	13.2
Quadratic effect of increasing proportion Brahman	−20.7	19.7
Angus vs Hereford as base breed	46.6**	15.1
Spring vs fall	47.5**	5.7
Linear × season interaction	65.9*	30.2
Quadratic × season interaction	8.4	43.3
Base × season interaction	−75.1*	34.0
Linear × base interaction	3.0	13.2
Quadratic × base interaction	39.4	20.0
Linear × season × base interaction	28.4	30.2
Quadratic × season × base interaction	−81.1	43.3

[a]Different from zero; * $P < .05$, ** $P < .01$.

S interaction was significant; therefore, the interaction least squares means were used. Overall, 60.3% of heifers exposed to breeding weaned a calf. This average is slightly lower than that found by Peacock et al. (1971), who reported a weaning rate of 71% for cows containing either 0, 25, 50, 75 or 100% of B breeding. In this study, %W ranged from 0% for fall-calving B·H to 88.5% for spring-calving $B_1H_1A_2$. Increasing proportion B breeding linearly decreased %W. The contrast evaluating the interaction between linear increase of proportion B and S indicates that as proportion B increased, the difference between spring- and fall-calving cows increased in favor of spring-calving groups. The trend of %W decreasing as proportion Brahman increased was expected based on similar trends in percent detected in heat and percent pregnant as reported by Bolton et al. (1987b). The quadratic effect of increasing proportion B was not significant. The contrast evaluating the effects of base breed indicates that females from A dams weaned significantly higher percentages than did those from H dams. A significant base breed × season of calving interaction indicates that differences across seasons were smaller between groups out of A dams than those between groups out of H dams. Significance of these contrasts indicates that cows out of A dams were more capable of handling the stresses associated with breeding during the coldest time of the year. Spring-calving cows weaned higher ($P < .01$) percentages than did fall-calving cows. The differences between spring- and fall-calving groups may be due in part to the anestrus-like behavior of B and B crosses during the winter months, similar to that reported by Plasse et al. (1968).

Linear contrasts evaluating differences between CG, S and SX are presented in Table 5 for birth and weaning traits. Percentage of cows requiring assistance at birth ranged from 5.8% for B·A to 31.9% for $B_1A_1H_2$. Overall, 21.0% required assistance at calving. Belcher and Frahm (1979) reported a similar average of 27.9% for 2-yr-old crossbred cows. Linear contrasts evaluating differences between CG were not significant, with the exception of the quadratic effect of increasing proportion B breeding. The linear effect of increasing proportion B approached significance (P = .11), indicating a trend of decreasing assistance being required as proportion B increased; this equates to a 12.7% decrease for 1/2 B vs 0 B cows. The negative value obtained for the quadratic effect of increasing proportion B indicates that 1/4 B cows, on average, required more assistance than the average of the 1/2 B cows. No differences existed between spring- and fall-calving groups for %A. Cows giving birth to bull calves required 19.3 percentage points more assistance than did those giving birth to heifer calves. This difference may be attributable to differences in BW; bull calves averaged −3.5 kg heavier ($P < .01$) at birth than female calves. These findings tend to agree with those of Roberson et al. (1986), who reported that bull calves were 2.5 kg heavier at birth than heifer calves were. Spring-born calves averaged 1.9 kg heavier (P

TABLE 5. LINEAR CONTRASTS OF LEAST SQUARES MEANS FOR PERFORMANCE TRAITS.

Contrast[a]	%A[b]	Birth weight	ADG	Weaning weight[c]	Conformation score	Condition score	Hip height[c]	Cow weight[d]
Linear (L)	−25.4	−1.1	.26**[e]	57.1**	.56	.02	6.0**	−25.4
Quadratic (Q)	−50.3*	−2.9	−.17**	−31.9**	−.73	−.21	−1.2	48.6
Base (B)	−29.3	−2.8	−.04	−8.4	−.26	−.07	.6	18.2
L × B	5.6	−.1	−.01	2.6	−.37	−.48*	−.5	−10.1
Q × B	−14.0	−1.9	−.04	−4.4	−.01	.13	1.1	37.7
Season	6.1	1.9	.02	4.6	.15	−.08	−12.4**	−45.9**
Sex	−19.3*	−3.5**	−.09**	−8.0*	.13	.15	1.7	

[a]Linear = linear effect of increasing proportion Brahman; Quadratic = quadratic effect of increasing proportion Brahman; Base = effect of base breed.

[b]Percentage of cows requiring assistance at birth.

[c]Adjusted to 205-d and 240-d basis for spring- and fall-calving groups, respectively.

[d]Prebreeding cow weight.

[e]Different from zero; * $P < .05$, ** $P < .01$.

= .07) at birth than fall-born calves. Roberson et al. (1986) reported significant seasonal effects on birth weight; calves born in January–March averaged 32.5 kg, those born in April–June averaged 34.2 kg and calves born in October–December averaged 32.1 kg. No differences were found between CG for BW.

Linear and quadratic effects of increasing proportion B indicated that as proportion B increased, ADG and WW increased (Table 5). Least squares means indicate that calves from 1/2 B cows gained an average of .14 kg/d faster and were 28.5 kg heavier at weaning than calves from 0 B cows. Spring-born calves tended to gain slightly faster than fall-born calves. Steer calves out-gained heifer calves by .09 kg/d and were 8.0 kg heavier at weaning. No differences were found in conformation scores attributable to CG, S or SX. However, contrasts of least squares means indicate a trend toward increased conformation scores as proportion Brahman increased, thus indicating an increase in the degree of muscling. The only significant contrast in the evaluation of condition score was the linear effect of increasing proportion B × base breed interaction. Calves out of 1/2 H cows tended to receive higher condition scores than calves out of 1/2 A dams. These differences increased as proportion B increased. Age-adjusted weaning hip height was significantly affected by the linear increase in proportion B breeding. As proportion B increased, WH increased. Season of birth significantly affected WH; fall calves, on the average, were 12 cm taller at weaning than spring calves. This difference can be attributed partially to the different ages of the calves at weaning.

Linear contrasts evaluating the effects of breed group on CW at breeding were not significant. The overall average CW was 308 kg. Cow weight was significantly affected by season; fall-calving cows were, on average, 46 kg heavier at the start of the breeding season than were their spring-calving counterparts. Thus, differences in %W cannot be attributed to differences in CW.

Implications

Because crossbreeding is used to increase production efficiency, performance of females as 2-yr-olds is important economically. The earlier in life a heifer becomes productive, the lower the cost of replacements. Data obtained in this study indicate that reproductive rates decreased as proportion Brahman breeding increased. Differences in reproductive rates were greater between fall-calving crossbred groups than between spring-calving crossbred groups. Growth traits improved as proportion Brahman increased. These differences in performance, in part, may be attributable to differences in rate of development and sexual maturity of the different crossbred groups. Thus, as these cows mature, the relative ranking of these groups may change. Based on reproductive and growth rates, spring calving appears to be more advantageous than fall calving.

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