Beef Production from Straightbreds and Reciprocal Crosses of Angus, Brahman, and Charolais Cattle

December 1979 Bulletin 810 (technical)

Agricultural Experiment Stations
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INTRODUCTION

Crossbreeding of beef cattle has been widely used to achieve improvements in beef production. The appropriate choice of breeds in crossbreeding depends upon the additive genetic merit of the breeds involved and heterosis resulting from the crossing of these breeds. Information on average breed effects and heterosis levels in various crosses thus are important to commercial producers.

This paper presents data on results from straight breeding and reciprocal crossbreeding of cattle of the Brahman, Charolais, and Angus breeds. These breeds were selected for the study because of their distinctive characteristics and availability for commercial production in Florida and the southeastern United States. The Charolais breed is noted for muscling and size; the Brahman for adaptability to the subtropical environment and combining ability with other breeds; the Angus for generally good fertility and carcass quality. These breeds represent three divergent breed types of importance in the United

States. The Charolais represents the large European beef breeds, the Brahman represents *Bos indices* cattle and the Angus represents cattle of British origin. The data presented include those for reproductive performance, weaning traits of calves, and annual production per cow.

MATERIALS AND METHODS

The research was conducted at the University of Florida Agricultural Research Center, Ona, Florida, from 1963 to 1974. The center is located 27°25' north latitude, 81°55' west longitude on low-fertility, sandy soil. Average annual rainfall is 54 inches with 75% of the precipitation occurring between May and October. The climate is semi-tropical with temperate intrusions during the winter. These intrusions are characterized by repeated frost periods with temperatures of 28° to 34°F, with lower temperatures occurring at less frequent intervals.

The herds were maintained on improved grass pastures composed predominately of Pangola digitgrass *(Digitaria decumbens),* moderately fertilized. The cattle were supplemented with 5 pounds of either molasses or citrus pulp-cottonseed meal (4:1 ratio) per head per day for approximately 90 days during late winter and early spring.

The design used to produce straightbred and firstcross (F_1) progeny is shown in Table 1. Sires of each breed were exposed each year to cows of each of the three breeds, in a balanced design. A total of 27 sires were used in the project, nine for each of the three breeds. Sires were selected subjectively to be representative of their breed. Females were selected in a similar manner. Cows were culled from the herd annually for unsoundness or reproductive failure; herd replacements averaged 19.6% per year. The mating season was restricted to 90 days beginning in early March. Male calves were castrated shortly after birth. Calves were weaned all at one time at an average age of 222 days.

Table 1. Number of matings by breed of sire and breed of dam.

	Breed of sire			
Breed of dam	Angus	Brahman	Charolais	Total
Angus	126	107	112	345
Brahman	118	128	121	367
charolais	128	116	136	380
Total	372	351	369	1092

DATA ANALYSES

The criteria for evaluating reproductive performance were pregnancy rate, calf survival rate, and weaning rate. Pregnancy rate was expressed as the percentage of cows exposed to bulls which were diagnosed pregnant by palpation in late August. Survival rate was expressed as the percentage of pregnant cows which weaned calves. Weaning rate was computed as the product of pregnancy and survival rates.

Individual calf records were maintained for date of birth, survival, sex, age at weaning, weaning weight, estimated 205-day weight, and condition score. Condition scores of 6, 7, and 8 were used to designate low, medium, and high standard calves; 9 to 11, good calves; and 12 to 14, choice calves. Average production per cow was computed as the product of weaning weight x weaning rate.

Statistical analyses were performed by usual least squares procedures as described by Harvey (2). The analyses shown in Tables 2 and 3 appeared to be the most appropriate for this study. The objective was to obtain unbiased estimates of breed-of-sire x breed-of-dam subclass means. Year and age of dam (3 years, 4 years, and mature) effects were included in the analyses for statistical precision. Significant levels between means were determined by the *standard t* test (Peacock *et al.*, 5; Peacock *et al.*, 6).

EXPERIMENTAL RESULTS

The analyses of variance for reproduction and production traits are shown in Tables 2 and 3, respectively. The means for reproduction traits are presented in Table 4 and those for production traits in Table 5. Observed heterosis levels (percent advantage of crossbreds over the average of parental breeds) are presented in Tables 4 and 5. Breed of sire, breed of dam, and breed of sire x breed of dam interaction were the items of primary interest in this study.

REPRODUCTION

Pregnancy Rate. The least squares mean for pregnancy rate was 78.6%. Breed of sire had significant effects ($P<0.05$) on pregnancy rate, being lowest for Angus sires (74.4%), intermediate for Charolais sires (79.1%) and highest for Brahman sires (82.3%). Peacock *et al.*. (7), at the same location, reported a pregnancy rate of 76% for Brahman bulls vs 72% for Shorthorn bulls ($P<0.05$). Similar results were reported by Turner *et al.* (11) with cows mated to Brahman bulls having the highest pregnancy rate and those mated to Angus bulls the lowest. However, data reported by Crockett *et al.* (1) from the Everglades area of south Florida showed that Angus and Hereford bulls had higher calf crops than Brahman bulls.

Differences in pregnancy rate were not significantly influenced by breed of dam (Table 2). These results did not agree with those of Crockett *et al.* (1), who reported birth rate for Angus cows to be 88.7% as compared with 73.7% for Brahman cows Research in Louisiana (Turner, *et al., 11),* however, agreed with results from the present study, showing Brahman cows to have a higher calving percentage (78.0%) than Angus (71.3%) or Hereford (72.8%) cows. Research by Peacock *et al. (7)* on straightbreeding and reciprocal crossing of the Brahman and Shorthorn cattle also showed a higher average pregnancy rate for the Brahman cows, 71% vs 64% for Shorthorns. In the present study, pregnancy rates for cows mated to produce crossbred calves (77.1%) were slightly lower (P<O.10) than those for cows mated to produce straightbred calves (81.5%).

Table 2. Mean squares from variance analyses of reproductive traits.

Source	Degrees of freedom	Pregnancy rate	Survival rate	Weaning rate [b]
Year	10	.9327**	.0446	--
Age of dam	2	.7868**	.2408**	--
Breed of sire (S)	2	.5632*	.0352	32.68
Breed of dam (D)	2	.0019	.6345**	60.82*
S x D	4	.3039	.0780	56.09**
Within	a	.1480	.0485	16.06
df in error		(1071)	(842)	(793)

[a]Shown in parentheses under error.

[b]Proximate analysis of mating group means (pregnancy rate x survival rate).

*P<0.05

**P<0.01

Table 3. Mean squares from variance analyses of weaning traits.

Source	IF	Age at weaning	Condition	Weaning weight	205-day weight	Annual prod/cow[a]
Year	10	9277**	9.7**	236**	401**	--
Sex	1	1345	38.4**	1447**	1583**	--
Age of dam	2	6609**	10.7**	876**	290**	--
Breed of sire	2	11742**	16.0**	2593**	1369**	534
Breed of dam	2	9988**	0.4	2877**	3501**	931*
S x D	4	595	17.7**	698**	691**	250
Within	795	861	1.4	44	21	289.5

[a]From a proximate analysis of mating group subclass means (weaning rate x weaning weight).

*P<0.05

**P<0.01

Calf Survival. Calf survival is an important factor affecting net reproductive efficiency. Survival rate was influenced significantly by breed of dam, but not by breed of sire (Table 2). The average survival rate for all calves was 94.3% (Table 4). This value was lower than that of 96.0% reported by Peacock *et al.* (7), but higher than the 92.0% observed by Turner *et al. (11)* or the 88.5% reported by Crockett *et al. (1).*

Survival rates were 88.7%, 97.2%, and 96.9% (P<0.01), respectively, for calves from Angus, Brahman, and Charolais dams (Table 4). There were no significant breed of sire x breed of dam interactions. Mean survival rates were 87.0%, 86.5%, and 92.6%, respectively, for Brahman x Angus, Charolais x Angus, and Angus x Angus calves. Average survival rates for all straight bred and F_1 calves were 94.3% and 94.2%, respectively. Turner *et al. (11)* reported survival rates of 80.5% for Brahman x Angus and 92.6% for Angus calves, which were similar to the results obtained during this study.

Sagebiel *et al.* (10) reported significantly higher dystocia scores for Angus cows than for Hereford and Charolais cows. Pahnish *et al.* (4) reported no heterosis for birth weights of F_1 Angus x Charolais calves, while reciprocal F_1 Charolais x Angus calves showed heterosis levels of 4.6% and 5.1%, respectively, for males and females.

Weaning Rate. Weaning rate was computed as the product of calving and survival rates. Breed of sire effects were nonsignificant. Breed of dam effects were significant, and there was a highly significant breed of sire x breed of dam interaction (Table 2).

The overall least squares mean for weaning rate was 74.1%. Comparative rates by breed of dam were 69.8%, 76.5%, and 75.9%, respectively, for Angus, Brahman and Charolais cows (Table 4). The average values for reciprocal combinations were 70.0% for Angus Brahman, 67.7% for Charolais-Angus, and 80.2% for CharolaisBrahman. Weaning rates were 76.9% for straightbred calves and 72.7% for F calves.

The breed of sire x breed of dam interaction is of special interest, since the merit of crossbreeding is determined by the additive genetic merit of each breed plus that achieved through interaction effects. The Charolais x Angus cross resulted in the lowest weaning rate (63.8%) while the Charolais x Brahman cross was highest (82.2%). The differences were due mainly to the relatively low survival rate for Charolais x Angus calves (86.5%) and high survival rate (99.6%) for Charolais x Brahman crosses.

The advantages for crossmated groups over the mean of the straightbred groups are presented in Table 4. Considering the three characteristics measured as calf traits, heterosis was negative for all breed combinations and traits except survival and weaning rate for Brahman-Charolais crosses.

Table 4. Least squares means for reproductive traits by mating groups

Group or effect[a]	Number of matings	Pregnancy rate	Calf Survival	Weaning rate [b]
Mu	1092	78.6%	94.3%	74.1%
1. A x A	126	79.2	92.6	73.3
2. B x B	128	84.3	94.3	79.5
3. C x C	136	81.1	96.1	77.9
4. A x B	118	69.6	97.6	67.9
5. B x A	107	83.0	87.0	72.2
6. A x C	128	74.4	96.2	71.6
7. C x A	112	73.7	86.5	63.8

8. B x C	116	79.5	98.5	78.3
9. C x B	121	82.5	99.6	82.2
Angus sires	372	74.4	95.5	70.9
Brahman sires	351	82.3	93.3	76.7
Charolais sires	369	79.1	94.1	74.6
Angus dams	345	78.6	88.7	69.8
Brahman dams	367	78.8	97.2	76.5
Charolais dams	380	78.3	96.9	75.9
Purebreds	390	81.5	94.3	76.9
Crossbreds	702	77.1	94.2	72.7
Advantage for crossmating				
Ho(AB)[c],1/2 (4†5-1-2)		-5.5	-1.2	-6.4
Ho(AC), 1/2(6†7-1-3)		-6.1	-3.0	-7.9
Ho(BC), 1/2(8†9-2-3)		-1.7	3.8	1.6
Advantage as percent of purebred average				
Ho(AB)		-6.7	-1.3	-8.4
Ho(AC)		-7.6	-3.2	-10.4
Ho(BC)		-2.1	4.0	2.0
[a]Breed designation:A, B, and C indicate Angus, Brahman, and Charolais, respectively. Breed of sire shown first for mating groups.				
[b]Weaning rate x weaning weight.				
[c]Breed combinations enclosed in parentheses include reciprocal matings combined.				

WEANING TRAITS

Age of Calf at Weaning. When mating occurs in a restricted season and all calves are weaned at one time, age of calf at weaning becomes an important production trait influencing the weight of calf at weaning. Consequently, age at weaning was analyzed as a production trait in this study. The overall least squares mean for age at weaning was 222.4 days.

A number of responses may influence this trait, including length of gestation, interval from parturition to first estrus, aggressiveness and mating ability of bulls, and fertility of both males and females once coupling is achieved.

Significant ($P<0.01$) differences in weaning age occurred for breed of sire and breed of dam, with no significant breed of sire x breed of dam interaction (Table 3). Age at weaning for straightbred matings was 211.4, 224.5, and 235.3 days, respectively, for Brahman, Charolais, and Angus breeds. Breed of sire and breed of dam effects, respectively, pooled over all groups, were 214.8 and 217.9 days from Brahman, 227.3 and 219.6 for Charolais, and 225.1 and 229.6 for Angus breeds. Age at weaning for crossbred calves was intermediate between weaning ages of parent breeds with no indication of heterosis for this trait.

Positive effects on age at weaning by both Angus sires and Angus dams suggest that length of gestation was an important factor in breed effects in this project. This indication is supported by the report of Sagebiel *et al.* (9), showing a shorter gestation period for the Angus than for the Charolais (279 vs 285 days), and a report by Plasse *et al.* (8) showing gestation length (291 days) in the Brahman breed to be considerably longer than those reported for the British breeds.

Condition score. This trait is of interest because it is known to be influenced by important factors, including breed characteristics, general well-being of the calf, and maternal ability of the dam. Up to the point of optimum degree of fatness there is a positive relationship between condition score and market value.

The mean condition score was 9.6, slightly less than average good in terms of federal grade. Scores were influenced significantly ($P<0.01$) by year, sex of calf and age of dam (Table 3). The condition scores for straightbred calves were 8.9 for Brahman and 9.4 for Angus and Charolais ($P<0.05$). Mean scores of breed of dam varied only from 9.6 to 9.7 (Table 5). Mean scores by breed of sire were 9.4, 9.6, and 9.9, respectively for the Brahman, Charolais, and Angus breeds ($P<O.O1$) These differences are in agreement with the general evaluation of these breeds with respect to the ratio of fat to lean.

Heterosis levels for each of the breed combinations were highly significant, amounting to 9.8%, 5.5%, and 5.3%, respectively, for the reciprocal Angus-Brahman, Charolais-Brahman, and Angus-Charolais crosses. These results are in agreement with other reports generally showing high levels of heterosis in Brahman-British breed crosses (Koger *et al.*, 3).

Calf Weight. The effects of the different variables on weaning weight and estimated 205-day weight were almost identical. The results from weaning weight only, therefore, will be discussed. All variables included in the model had highly significant effects on calf weights (Table 3).

The weaning weights of the straightbred groups were 390, 398, and 519 pounds, respectively, for the Angus, Brahman, and Charolais calves (Table 5). Weights of the crossbred groups varied from 506 pounds for C x B to 437 pounds for B x A calves. The average weight for all crossbreds exceeded that for the straightbreds by 30 pounds, or 6.9%.

Heterosis levels were a highly significant 12% for A-B and 7% for C-B but a nonsignificant 2% for A-C crosses. These results indicate high levels of heterosis among crosses of the British and Brahman breeds but only low levels from crossing the Angus and Charolais breeds.

Table 5. Least squares mating group means, and calf heterosis for weaning traits.

Mating[a] group	**Number of observations**	**Age at weaning**	**Condition**	**Weaning weight[b]**	**205-day weight**	**Production/ Cow[b]**
		days	score	lbs	lbs	lbs
Mu	817	222.4	9.6	456	428	338
1. A x A	94	235.3	9.4	390	351	286
2. B x B	103	211.4	8.9	398	392	317
3. C x C	107	224.5	9.4	519	482	404
4. A x B	80	219.5	10.2	447	423	303
5. B x A	75	219.1	9.8	437	417	316
6. A x C	94	220.3	10.0	477	451	342
7. C x A	72	234.5	9.7	450	405	287
8. B x C	93	213.8	9.5	477	462	373

9. C x B	99	222.9	9.7	506	472	416
Angus sires	268	225.1	9.9	438	408	311
Brahman sires	282	214.8	9.4	437	424	335
Charolais sires	294	227.3	9.6	492	453	367
Angus dams	241	229.6	9.6	426	391	297
Brahman dams	282	217.9	9.6	450	429	344
Charolais dams	294	219.6	9.7	491	465	373
Purebreds	304	223.7	9.2	436	408	336
Crossbreds	513	221.7	9.8	466	438	340
Heerosis in units of measurement						
Ho(AB)[c],1/2 (4†5-1-2)		-4.0	0.9	48	48	9
Ho(AC), 1/2(6†7-1-3)		-2.5	0.5	9	11	-30
Ho(BC), 1/2(8†9-2-3)		0.4	0.5	33	30	35
Heterosis as percent of purebred average						
Ho(AB)		-1.8	9.8	12	13	3
Ho(AC)		-1.1	5.3	2	3	-9
Ho(BC)		0.2	5.5	7	7	10

[a]Breed designation:A, B, and C indicate Angus, Brahman, and Charolais, respectively. Breed of sire shown first for mating groups.

[b]Weaning rate x weaning weight.

[c]Breed combinations enclosed in parentheses include reciprocal matings combined.

ANNUAL PRODUCTION PER COW

This trait is a measure of total production performance and is highly correlated with total economy of beef cattle production. It is a composite trait including genetic components for cow fertility, growth potential of the calf, calf survival, and maternal ability of the cow. Each of these components is in turn influenced by additive breed and heterosis effects.

The mean annual production per cow was 338 pounds of calf at weaning (Table 5). Of the nine breed-of-sire x breed-of-dam subclasses, the straightbred Angus group was the lowest with 286 pounds. This value was associated with the lowest weaning weight and the lowest weaning rate. The largest annual production of 416 pounds was from Brahman cows mated to Charolais bulls. This production level resulted from the highest weaning rate of 82% combined with the second highest weaning weight of 506 pounds. These values emphasize the impact of weaning rate on annual production rate.

Annual production by sire breeds pooled over all breeds of dams was 311, 335, and 367 pounds respectively for Angus, Brahman, and Charolais sires. Comparable values by breed of dam were 297, 344, and 373 pounds. These production levels parallel breed size, as might be anticipated.

Heterosis levels for annual production were -9%,3%, and 10%, respectively, for Angus-Charolais, Angus-Brahman, and Brahman-Charolais crosses. The low value for Angus-Charolais crosses was associated with genetic size and growth potential of the Angus breed and a high death loss among progeny of Charolais bulls mated to Angus cows. These results emphasize the need for compatibility in size of sires with that of dams to which they are mated, if high death losses in calves are to be avoided.

The heterosis level of 3% for reciprocal Brahman-Angus crosses resulted from a high level of heterosis for growth (12%) combined with a negative heterosis (-8.4%) for weaning rate, once again emphasizing the overriding importance of weaning rate in total performance.

DISCUSSION

It should be noted that this report presents the results from the first phase of a crossbreeding project designed to evaluate the Angus, Brahman, and Charolais breeds as straightbred and crossbreds. The crossbred heifers evaluated during the first phase of the project reported here will be carried forward into the second phase of the project, where they will be evaluated as crossbred dams.

The most important results from the first phase of the project were the following. (1) Hybrid vigor levels vary widely with breed combinations, as demonstrated by a heterosis level of 12% for weaning weight in Brahman-Angus crosses but only 2% in Angus-Charolais crosses. (2) Incompatibility in characteristics such as size of fetus and size of cow can lead to disasterous results in unwise breed combinations, as was demonstrated

by mating Charolais bulls to Angus cows in this trial. When the advantages for breed-cross matings over straightbred matings were calculated for the three reproductive traits, seven of nine of these differences were negative (Table 4). These breed combinations might be used successfully, however, where crossbred rather than straightbred cows are used as dams. This point will be elucidated during the second phase of the project, to be reported at a later date.

SUMMARY

Straightbred and reciprocal firstcross progeny of the Angus, Brahman, and Charolais breeds were produced by mating sires and females of the three breeds in aIl possible combinations in a balanced design. A total of nine sires of each breed were used over a period of 11 years. The data from 1092 matings, resulting in 863 pregnancies, and 817 complete weaning records were analyzed.

Mean pregnancy rates were 81.5% for straightbred matings and 77.1% for crossmatings (P<O.10). The effects of crossmating were negative for all breed combinations but not significantly so for the numbers involved. Pregnancy rates by breed of sire were 82.3%, 79.1%, and 74.4%, respectively, for Brahman, Charolais, and Angus sires. Pregnancy rates by breed of dam were almost identical.

Calf survival was significantly influenced by breed of dam (P<0.01). This result is explained on the basis of heavy death loss in calves from Angus cows mated to either Brahman or Charolais bulls (P<0.01) with heavy death losses apparently explained by difficult birth. Except for Angus cows, weaning rate closely paralleled pregnancy rate.

Earliness of calving (determined by age of calf at weaning) was negatively influenced by Brahman sires (P<0.01) and positively influenced by Angus dams. Heterosis effects for weaning age were negligible.

Condition scores of calves were negatively influenced by Brahman sires (P<0.01) and positively influenced by Charolais dams. Heterosis effects were significantly positive for all breed combinations, being 9.8%, 5.5%, and 5.3%, respectively, for Angus-Brahman, Brahman-Charolais, and Angus-Charolais crosses.

Weaning weights were 492, 438, and 437 pounds, respectively, for C, A, and B sires (P<0.01) and 491, 450, and 426 pounds for C, B. and A dams (P<0.01). Heterosis levels were 12%, 7%, and 2%, respectively, for A-B, B-C, and A-C crosses. Annual production per cow was strongly influenced by calf survival, resulting in low production rates for Angus cows mated to either Charolais or Brahman bulls.

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