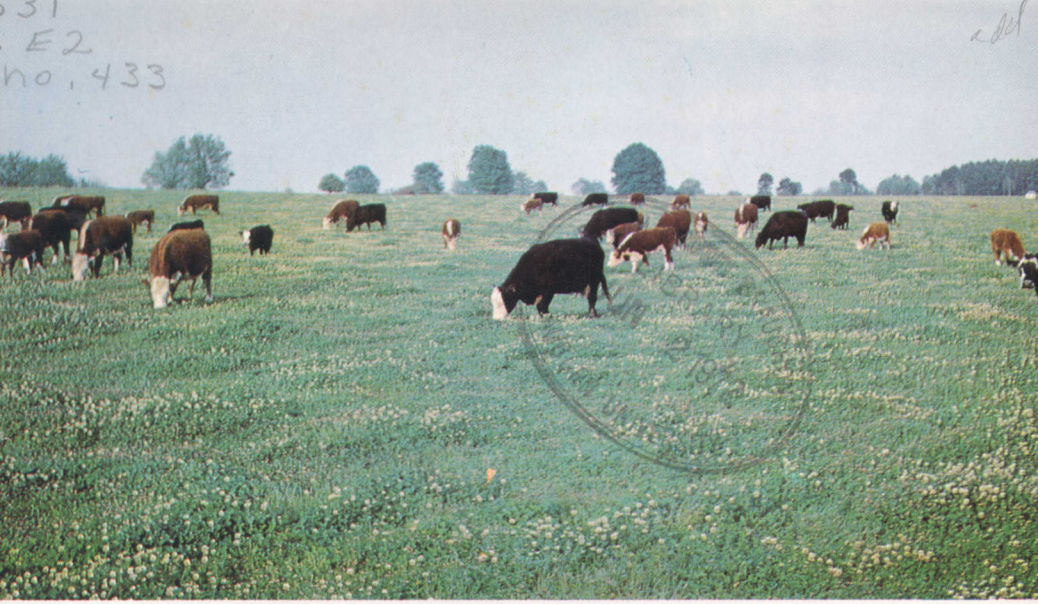

CROSSBREEDING BEEF CATTLE

value of crossbreeding for commercial cattle production shown in long-time research at Black Belt Substation

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CROSSBREEDING BEEF CATTLE

Value of Crossbreeding for Commercial Cattle Production Shown in Long-Time Research at Black Belt Substation

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L. A. SMITH and HAROLD GRIMES[1]

THE PHENOMENON OF HETEROSIS, or "hybrid vigor," has long been observed in domestic plants and animals. Plant and animal breeders now recognize and accept crossbreeding as a method of improving production. Nearly all corn and a high percentage of many other crops produced in the United States are the result of crossing inbred lines. It has been estimated that three-fourths of the market hogs produced in the United States are crossbred. The poultry industry has made great improvement in broiler growth rate and feed efficiency by using highly specialized hybrids and, to a lesser extent, hybrids layers have been used for the production of eggs.

Commercial crossbreeding of beef cattle has been centered in the Southern United States. In the Gulf Coast Region, Brahman bulls have been crossed with native and British breed cows for improved production and greater tolerance to heat and insects. British breed bulls have been used in a rotational backcross program, or as a third breed, with the part-Brahman cows.

Crossbred females have been highly productive, but perhaps of greatest importance is the reproductive efficiency associated with crossbreeding. Several workers reported higher calving rates as a result of crossing two breeds *(5,11,31,34,38)*. Others have shown that crossbred females drop and wean a significantly

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higher percentage calf crop than straightbred females *(5,22,30,33, 34,37,38).*

Many workers have reported that crossbred calves were heavier at birth *(5,7,8,10,11,13,14,16,20,21,24,31,35).* That three-breed cross calves were heavier than either two-breed or purebreds has been shown by others *(15,35).*

Crossbred calves from purebred cows were found to be heavier at weaning than purebreds *(1,2,8,11,13,16,20,21,31),* and three-breed cross calves heavier than either purebred or two-breed calves *(11,15,35).* Largely because of heterotic effect in the crossbred dams, backcross calves were heavier than straightbreds at weaning *(5,24,26,35).*

In general, crossbred calves gained faster post-weaning than did straightbred calves *(5,17,36).* However, the reverse was true for some specific crosses with weaning weights as heavy as or heavier than straightbred calves *(3,4,17).* Vogt *et al. (36)* reported that two-breed calves gained faster post-weaning than did three-breed calves.

Slaughter or feeder grades at weaning were found to be not significantly different among beef breeds and crosses unless the Brahman breeding of the calf exceeded 50 per cent *(6,8,9,11,16, 24,30,31,34).* Differences between purebred and crossbred carcass traits tend to be small and non-significant unless the trait is associated with weight *(3,4,9,12,13,21,35).*

Throughout these crossbreeding studies, specific breed crosses occasionally resulted in exceptions to these general findings.

EXPERIMENTAL PROCEDURE

The data reported here were obtained from research at the Black Belt Substation, Marion Junction, Alabama. These investigations began with the records of calves born in the 1950 calving season and ended with the post-weaning performance records of steer calves born during the 1966 calving season. Foundation cows used were high grade Herefords. The crossbred cows were produced at the Substation by mating the foundation Hereford cows to Brahman, Shorthorn, and Angus bulls. Replacement heifers produced on the Substation were added as needed to maintain the experimental herds.

To permit valid analyses, this study was divided into five periods.

Period I. A 6-year period (1950-55) in which Angus bulls were mated to Hereford and Brahman-Hereford cows.

Period II. The 4-year period (1952-55) in which Angus bulls were mated to Hereford, Brahman-Hereford, and Shorthorn-Hereford cows.

Period III. A 4-year period (1956-59) in which Hereford bulls were mated to Hereford, Brahman-Hereford, and Shorthorn-Hereford cows. This period extended into Period IV.

Period IV. A 5-year period (1956-60) in which Hereford cows were randomly assigned to be mated to either Angus or Hereford bulls. Brahman-Hereford cows were bred to the same Hereford bulls.

Period V. An 8-year period (1959-66) in which Hereford bulls were mated to Hereford, Angus-Hereford, and Hereford x (Brahman-Hereford) cows and Angus-Hereford cows were backcrossed to Angus bulls.

Throughout this investigation, each calf was numbered and each male castrated within 24 hours after birth. Sex, birth weight, birth date, and dam's number were recorded. During periods I, II, III, and IV, three weaning dates were selected each year so that the average weaning age of each group of calves would be approximately 250 days. All calves were individually weighed at weaning.

The project was revised in 1955, in a manner that allowed completion of Period III and at the same time initiated Period IV. Therefore, part of the data collected was common to both periods. Beginning with Period IV, slaughter grades were obtained on all calves at weaning.

In Period V steer calves were continued on a post-weaning performance test on the ration shown in Appendix Table 1.

After weaning calves were held in a small paddock for an adjustment period varying up to 24 days, during which time they were fed a limited amount of corn and cottonseed meal and johnsongrass hay *ad libitum*. Following the adjustment period, the steers were fed 5 pounds of corn per head daily on dallisgrass pasture. The actual weaning weight was used as the initial post-weaning test weight. Steers went from the pasture period to the feedlot for a finishing period averaging 144 days. The finished steers were slaughtered and carcass data obtained. These

data included carcass weight, ribeye area, fat thickness, and USDA quality grade.

Throughout the experiment heifers were bred to Angus bulls to calve as 2-year-olds. Data from 2-year-olds were included only in periods I and II, however, because in other periods some of the older cows were bred to Hereford bulls. Management practices for these heifers were as follows:

(1) From weaning (July-August-September) through October, they were fed a daily ration of 3 pounds of crushed ear corn while on pasture.

(2) During the winter months (November-February), they were fed daily 1½ pounds of 41 per cent cottonseed meal, 2½ pounds of crushed ear corn, and johnsongrass hay free choice (approximately 12 pounds).

(3) Beginning in late January the heifers were bred to Angus bulls and given access to pasture for the spring and summer months.

(4) As they began calving in November, they were fed johnsongrass hay free choice (approximately 20 pounds), 2 pounds of 41 per cent cottonseed meal, and 3 pounds of crushed ear corn daily.

(5) Calves from 2-year-old heifers were creep fed.

During the winter months brood cows, 3 years old and older, were fed 2 pounds of 41 per cent cottonseed meal per head daily plus johnsongrass hay *ad libitum*. Caley peas (wild winter) were grazed for approximately 50 days in early spring and permanent pasture, primarily dallisgrass and a small amount of white clover, from late spring until late fall. Salt was the only supplemental mineral provided. Calves were not creep fed.

Analysis of Data

The data were analyzed by periods using the least-squares procedures as described by Harvey *(19)*. Corrections were made for age of dam effects on 250-day weaning weights. Because of small subclass numbers, least-squares constants for age of dam were calculated by pooling all data from periods I through V (Appendix Table 2). Year, sex of calf, and breed groups were included as main effects. Regression analyses were used to account for the effects of date of birth of calf. Chi-square analyses were used for tests of significance of differences in reproductive performance. Tests of significance among individual least-squares

means were made with Kramer's (23) modification of Duncan's range test.

Separate analyses were made by periods for birth weight, average daily gain from birth to weaning, 250-day weight, and 250-day weight per day of age (appendix tables 3 through 8). The analyses for carcass traits are given in Appendix Table 9. The mathematical models used in the analyses are shown on page 26.

RESULTS AND DISCUSSION

Period I

The 6-year reproductive performance of Hereford and Brahman x Hereford cows when mated to Angus bulls is summarized in Table 1. Percentages of calves weaned per cow bred were 84.1 for the Brahman x Hereford cows and 80.4 for the Hereford cows. Although this difference is not significant, it is in agreement with reports of Turner *et al. (34)* and Cartwright *et al. (5)*.

Least-squares means for birth weights, 250-day average daily gains, and 250-day weights are reported in Table 2. Calves produced from Brahman x Hereford dams were slightly, but not significantly, heavier at birth than calves from Hereford dams. These differences are similar to those reported by Rhoad and Black *(29)*, Kidder and Chapman *(20)*, and Godbey *et al. (14)*.

TABLE 1. REPRODUCTIVE PERFORMANCE OF COWS[1], PERIOD I

Year	Hereford			Brahman-Hereford		
	Cows	Calved	Weaned	Cows	Calved	Weaned
	No.	*Pct.*	*Pct.*	*No.*	*Pct.*	*Pct.*
1950	9	100.0	100.0	12	83.3	83.3
1951	9	77.8	77.8	12	66.7	66.7
1952	19	79.0	79.0	19	89.4	89.4
1953	24	83.3	83.3	27	81.5	81.5
1954	26	76.9	73.1	35	91.4	91.4
1955	20	85.0	80.0	33	87.9	81.8
AVERAGE		82.2	80.4		85.5	84.1

[1] All cows were bred to Angus bulls.

TABLE 2. LEAST-SQUARES MEANS[1] OF PRE-WEANING TRAITS, PERIOD I

Breeding of calf	Number	Birth weight	250-day ADG	250-day WDA	250-day weight	250-day wt./cow bred
		Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*
A x H	72	58.8	1.61b	1.84b	461b	371b
A x (B x H)	107	61.5	1.81a	2.05a	513a	431a

[1] Means followed by different letters differ at $P<0.01$.

Calves from Brahman x Hereford dams had average daily gain of 1.81 pounds from birth to weaning, as compared with 1.61 pounds for calves from Hereford dams. Weaning weights were 513 and 461 pounds for the two breeding groups, respectively. These differences of 0.20 pound and 52 pounds are highly significant ($P<0.01$). They are in general agreement with previous reports of Lush *et al. (24),* Peacock *et al. (26,27),* Turner and McDonald *(35),* Warwick *(37),* and others who have shown that part-Brahman dams produce heavier calves at weaning than do straightbred British cows. The difference of 60 pounds of calf weaned per cow bred was highly significant ($P<0.01$).

Total number of calves included in pre-weaning performance (Table 2) is not in agreement with number of calves included in reproductive performance (Table 3). This is because calves born after January 1 were not included in pre-weaning data.

Period II

This 4-year period was analyzed separately since the Shorthorn x Hereford cows were added to the study in 1952. Thus, for comparative purposes, calves produced by the Hereford and Brahman x Hereford dams during the 1952 season and through the 1955 season were included in both Period I and Period II. All calves were sired by Angus bulls.

Table 3 gives reproductive performance of the different breeds of cows during Period II. Per cent calves born was 87.7, 83.6, and 80.9, respectively, for Brahman x Hereford, Shorthorn x Hereford, and Hereford cows. These differences were not significant.

Differences in per cent calves born and per cent calves weaned were 2.2, 1.7, and 1.6 for the Hereford, Brahman x Hereford, and

TABLE 3. REPRODUCTIVE PERFORMANCE OF COWS[1], PERIOD II

Year	Hereford			Brahman-Hereford			Shorthorn-Hereford		
	Cows	Calved	Weaned	Cows	Calved	Weaned	Cows	Calved	Weaned
	No.	*Pct.*	*Pct.*	*No.*	*Pct.*	*Pct.*	*No.*	*Pct.*	*Pct.*
1952	19	79.0	79.0	19	89.4	89.4	7	71.4	71.4
1953	24	83.3	83.3	27	81.5	81.5	15	66.7	66.7
1954	26	76.9	73.1	35	91.4	91.4	20	90.0	85.0
1955	20	85.0	80.0	33	87.9	81.8	19	94.8	94.8
AVERAGE		80.9	78.7		87.7	86.0		83.6	82.0

[1] All cows were bred to Angus bulls.

TABLE 4. LEAST-SQUARES MEANS[1] OF PRE-WEANING TRAITS, PERIOD II

Breeding of calf	Number	Birth weight	250-day ADG	250-day WDA	250-day weight	250-day wt./cow bred
		Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*
A x H	62	60.7	1.68c	1.92c	481c	379c
A x (S x H)	46	64.5	1.76b	2.01b	503b	412b
A x (B x H)	96	62.5	1.84a	2.09a	523a	450a

[1] Means followed by different letters differ at $P<0.05$.

Shorthorn x Hereford dams, respectively. These differences are in agreement with Temple and Miller *(33)*, Cartwright *et al. (5)*, Riggs *et al. (30)*, and Turner *et al. (34)*.

Least-squares means for pre-weaning traits are summarized in Table 4. Birth weights of calves from both groups of crossbred dams were slightly heavier than those from Hereford dams. These non-significant differences were 3.8 and 1.8 pounds, respectively, for calves from Shorthorn x Hereford and Brahman x Hereford. This is consistent with reports of Kidder and Chapman *(20)*, McCormick and Southwell *(25)*, and Godbey *et al. (14)*. It also agrees with Turner and McDonald *(35)* that three-breed cross calves are approximately 3 pounds heavier at birth than two-breed cross calves.

The average daily gain from birth to weaning of 1.84 pounds and 250-day weight of 523 pounds for calves from the Brahman x Hereford dams were significantly higher ($P<0.05$) than the average of 1.76 pounds and 503 pounds for calves produced by the Shorthorn x Hereford dams. Differences in average daily gain and 250-day weights were highly significant ($P<0.01$) between the calves from Brahman x Hereford dams and those from straightbred Hereford cows – 1.84 and 523 pounds and 1.68 and 481 pounds, respectively. These results are similar to those reported by Peacock *et al. (26,27)* and by Damon *et al. (8)*. The differences between calves from Shorthorn x Hereford dams and calves from straightbred Herefords were significant ($P<0.05$) for average daily gain and 250-day weight.

The differences in 250-day weights become even greater when they are compared as calf weight per cow in the herd at breeding.

Period III

This period includes 4 years (1956-59) in which Hereford bulls were mated to the same cows used in periods I and II.

TABLE 5. REPRODUCTIVE PERFORMANCE[1] OF COWS, PERIOD III

Year	Hereford			Brahman-Hereford			Shorthorn-Hereford		
	Cows	Calved	Weaned	Cows	Calved	Weaned	Cows	Calved	Weaned
	No.	*Pct.*	*Pct.*	*No.*	*Pct.*	*Pct.*	*No.*	*Pct.*	*Pct.*
1956	17	64.7	58.8	32	75.0	75.0	19	89.5	79.0
1957	13	84.6	76.9	31	77.4	77.4	17	88.2	82.4
1958	13	61.5	61.5	26	88.5	84.6	16	100.0	100.0
1959	11	100.0	81.5	22	100.0	86.4	16	87.5	81.3
AVERAGE		79.5b	68.5b		83.8b	80.2a		91.2a	85.3a

[1] Means followed by different letters differ at $P<0.05$.
[2] All cows were bred to Hereford bulls.

Per cent calves born and weaned were 91.2 and 85.3, 83.8 and 80.2, and 79.5 and 68.5, respectively, for Shorthorn x Hereford, Brahman x Hereford, and straightbred Hereford cows, Table 5. The Shorthorn-Hereford cows dropped a significantly higher percentage of calves than the other groups and all groups of crossbred cows weaned a significantly ($P<0.05$) larger percentage of calves than did straightbred cows. These results agree with those of Cartwright *et al. (5)* and Gaines *et al. (11).*

Least-squares means for birth weight, average daily gain, and 250-day weight are presented in Table 6. There was no significant difference in birth weights of calves from straightbred Hereford dams and those from Shorthorn x Hereford dams. However, both groups were significantly ($P<0.05$) heavier at birth than calves from Brahman x Hereford dams. These results are in agreement with Cartwright *et al. (5)* and Ellis *et al. (10),* but differ from reports by Lush *et al. (24)* and Godbey *et al. (14)* that calves from Brahman x Hereford dams were heavier at birth.

No significant differences were found among the three breeding groups in average daily gains and 250-day weights. The daily gains and 250-day weights of the calves from the Shorthorn x Hereford and Brahman x Hereford dams were approximately the same for Period III as for those reported for Period II,

TABLE 6. LEAST-SQUARES MEANS[1] OF PRE-WEANING TRAITS, PERIOD III

Breeding of calf	Number	Birth weight	250-day ADG	250-day WDA	250-day weight	250-day wt./cow bred
		Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*
H x H	37	67.4a	1.76	2.03	508	348c
H x (B x H)	89	63.7b	1.81	2.07	518	415b
H x (S x H)	58	67.7a	1.78	2.06	515	439a

[1] Means followed by different letters differ at $P<0.05$.

Table 6. However, average daily gain and 250-day weight of calves from Hereford dams were larger in Period III than in Period II. This may have been effected by the fact that 66 per cent of the Hereford cows were culled during periods I to III, as compared with only 20 per cent of the Shorthorn x Hereford and 39 per cent of the Brahman x Hereford cows. The differences become significant ($P<0.05$), however, when the comparison is on the basis of calf per cow bred. The Shorthorn x Hereford dams produced more pounds of calf per cow than the Brahman x Hereford dams. Both of these groups produced more pounds of calf than the Hereford cows.

Period IV

The percentage of calves born and weaned per cow bred was significantly larger ($P<0.05$) for the Brahman x Hereford cows than for the other two groups, Table 7. Calving percentages were 95.7 for Brahman x Hereford cows and 86.7 for the Hereford cows when both were mated to Hereford bulls. The Hereford cows mated to Angus bulls had a calving percentage of 78.8. Little difference was found among the groups in calf survival from birth to weaning. At least some of the poor performance of Hereford cows mated to Angus bulls can be explained by the use of a partially sterile bull during the 1960 season. Gaines *et al. (11),* Turner *et al. (34),* and Rollins *et al. (31)* report that Hereford cows mated to Angus bulls produce a larger percentage of calves born and weaned than do Hereford cows mated to Hereford bulls. However, Wiltbank *et al. (38)* found no difference in percentage of calves weaned from Hereford cows mated to Hereford bulls as from Hereford cows mated to Angus bulls.

TABLE 7. REPRODUCTIVE PERFORMANCE[1] BY BREEDING GROUPS, PERIOD IV

Year	Hereford x Hereford			Angus x Hereford			Hereford x Brahman-Hereford		
	Cows	Calved	Weaned	Cows	Calved	Weaned	Cows	Calved	Weaned
	No.	*Pct.*	*Pct.*	*No.*	*Pct.*	*Pct.*	*No.*	*Pct.*	*Pct.*
1956	22	95.5	90.9	17	100.0	94.1	15	100.0	100.0
1957	22	95.5	90.9	16	87.5	87.5	18	88.9	88.9
1958	20	85.0	80.0	18	72.2	72.2	22	90.9	86.4
1959	14	78.6	78.6	21	71.4	61.9	20	100.0	90.0
1960	12	66.7	58.3	13	61.5	53.9	18	94.4	83.3
AVERAGE		86.7b	82.2b		78.8c	74.1c		95.7a	90.3a

[1] Means followed by different letters differ at $P<0.05$.

TABLE 8. LEAST-SQUARES MEANS[1] OF PRE-WEANING TRAITS, PERIOD IV

Breeding of calf	Number	Birth weight	250-day ADG	250-day WDA	250-day weight	250-day wt./cow bred	weaning score[2]
		Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	
H x H	74	67.6a	1.72b	1.99b	497b	409b	10.2a
A x H	63	65.7ab	1.72b	1.98b	495b	367c	9.1b
H x (B x H)	84	64.5b	1.80a	2.05a	513a	463a	9.4b

[1] Means followed by different letters differ at $P<0.05$.
[2] Grade code: 9 = low Good; 10 = average Good; 11 = high Good, etc.

Pre-weaning performances, birth weights, average daily gains from birth to weaning, and 250-day weights are given in Table 8. Straightbred Hereford calves were significantly ($P<0.05$) heavier at birth than calves out of Brahman x Hereford dams. There were no significant differences in birth weight among the other groups. These results agree with Cartwright *et al. (5)* and Ellis *et al. (10).*

Calves from Brahman x Hereford dams gained faster and were heavier at 250 days of age ($P<0.05$) than were calves from the Hereford dams. Although straightbred Hereford and Angus x Hereford calves did not differ significantly for 250-day weight, the difference in 250-day calf weights per cow was significant ($P<0.05$).

PERIOD V

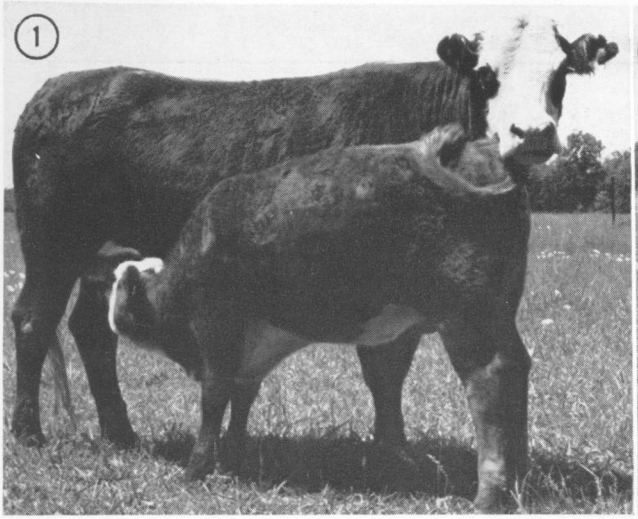
Angus x Hereford cows gave birth to a larger percentage ($P<0.05$) of calves than any other breed group, Table 9. Most of this difference resulted from a greater survival rate of calves sired by Hereford bulls. No significant differences existed among the other groups.

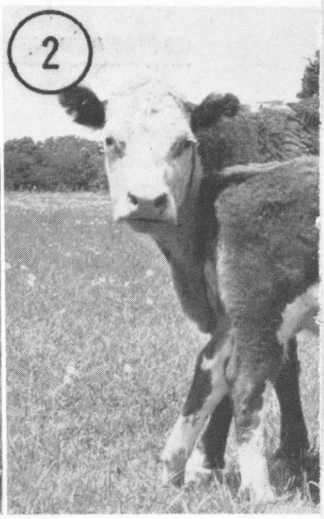
Least-squares means of calf performance from birth to 250 days of age are presented in Table 10. No significant differences were found among birth weights of the various groups of calves. Calves produced by the Angus x Hereford dams, regardless of breed of sire, were significantly ($P<0.01$) heavier at 250 days of age than straightbred Hereford calves. This agrees with reports of Gaines *et al. (11)* and Turner and McDonald *(35).* Calves from the Hereford x (Brahman x Hereford) dams were significantly heavier ($P<0.01$) at 250 days of age than the straightbred Hereford calves but significantly lighter ($P<0.01$) than calves from

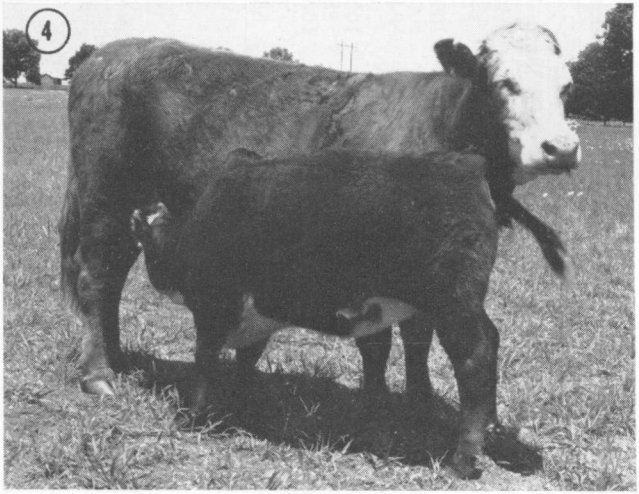
TABLE 9. REPRODUCTIVE PERFORMANCE[1] BY BREEDING GROUPS, PERIOD V

Year	Hereford x Hereford			Hereford x Angus-Hereford			Hereford x Hereford-(Brahman-Hereford)			Angus x Angus-Hereford		
	Cows	Calved	Weaned	Cows	Calved	Weaned	Cows	Calved	Weaned	Cows	Calved	Weaned
	No.	*Pct.*	*Pct.*	*No.*	*Pct.*	*Pct.*	*No.*	*Pct.*	*Pct.*	*No.*	*Pct.*	*Pct.*
1959	3	100.0	100.0	6	100.0	100.0	4	100.0	100.0	0	00.0	00.0
1960	9	100.0	100.0	7	85.7	85.7	8	100.0	100.0	5	100.0	100.0
1961	16	75.0	75.0	8	100.0	100.0	18	84.3	77.8	9	88.9	88.9
1962	23	78.3	73.9	12	83.3	83.3	23	70.0	70.0	13	84.6	76.9
1963	21	85.7	83.7	13	100.0	100.0	29	100.0	100.0	14	92.9	85.7
1964	20	90.0	90.0	11	100.0	100.0	27	88.9	85.2	15	100.0	100.0
1965	16	93.8	93.8	14	100.0	100.0	26	100.0	92.3	13	100.0	100.0
1966	17	94.1	88.2	16	93.8	93.8	24	79.2	79.2	9	88.9	77.8
AVERAGE		87.2b	86.4b		95.4a	95.4a		88.7b	86.2b		92.3a	85.9b

[1] Means followed by different letters differ at $P<0.05$.







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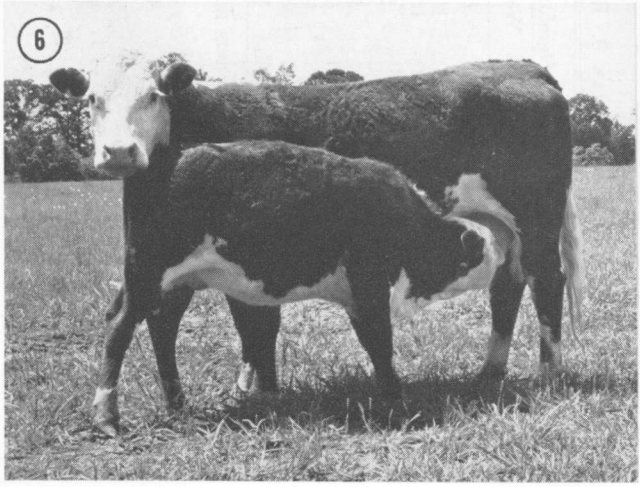

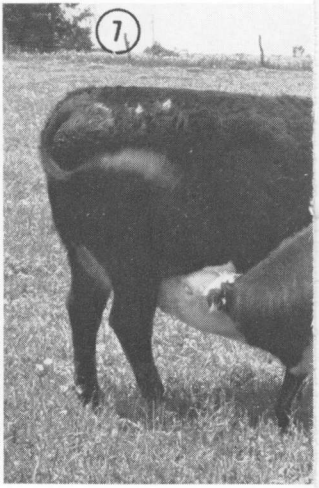

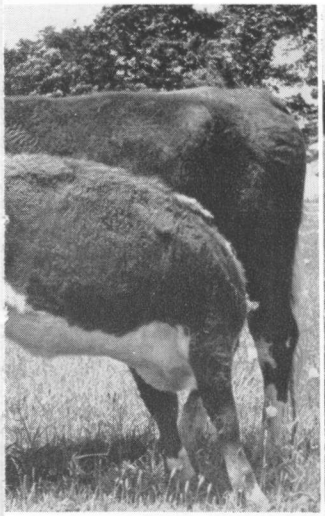

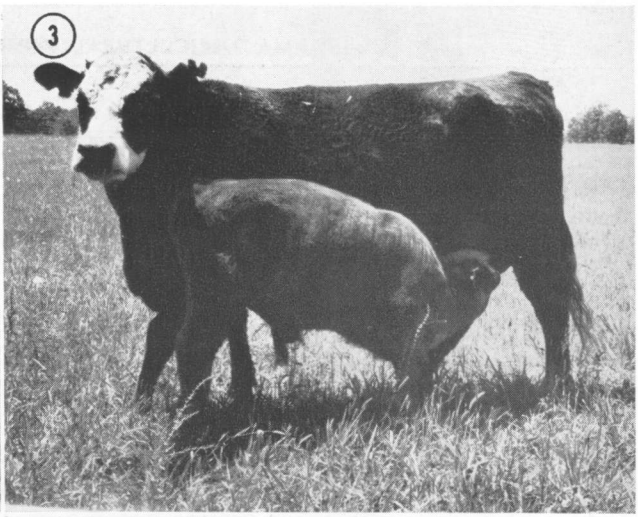

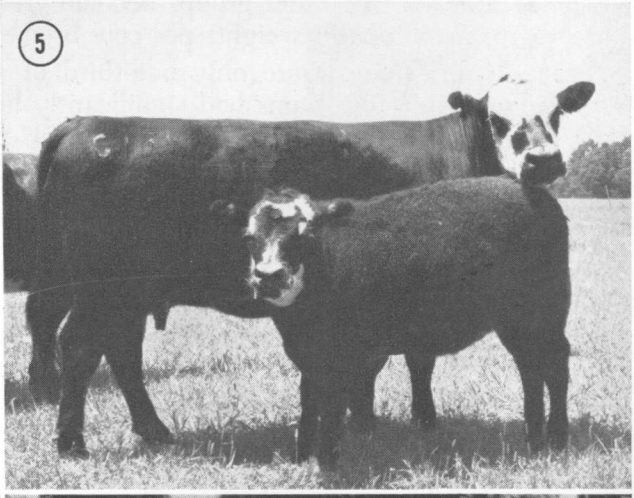

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ted in the crossbreeding
Belt Substation, Marion
¾ Hereford-¼ Brahman
Brahman calf; 2. Here-
Angus-½ Hereford cow
rd calf; 4. ½ Brahman-
2 Angus-¼ Brahman-¼
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8. ½ Angus-½ Here-
d-¼ Angus calf. Photo-
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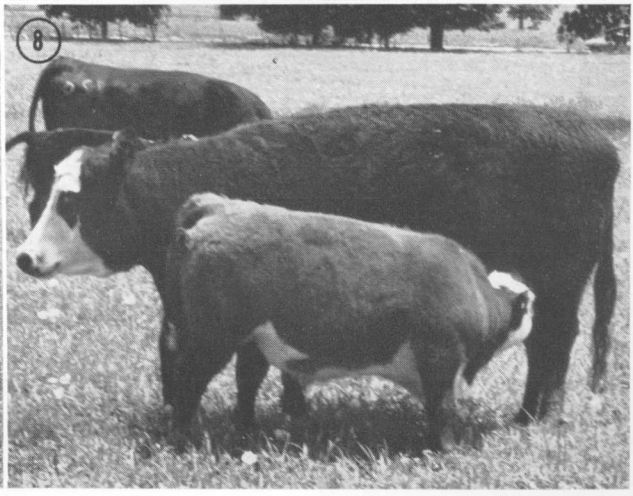

TABLE 10. LEAST-SQUARES MEANS[1] OF PRE-WEANING TRAITS, PERIOD V

Breeding of calf	Number	Birth weight	250-day ADG	250-day WDA	250-day weight	250-day wt./cow bred	Weaning score[2]
		Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	
H x H	108	66.2	1.55c	1.82c	454c	392c	9.3b
A x (A x H)	67	64.2	1.73a	1.99a	497a	427b	10.4a
H x (A x H)	83	64.6	1.76a	2.02a	505a	482a	10.3a
H x H (B x H)	138	65.5	1.65b	1.91b	477b	411b	9.5b

[1] Means followed by different letters differ at $P<0.01$.
[2] Grade code: 9 = low Good; 10 = average Good; 11 = high Good, etc.

the Angus x Hereford dams. Differences between 250-day weights of calves from Angus x Hereford dams and sired by Hereford bulls and the other groups become greater when comparisons are made of calf weights per cow bred.

Although differences were only one-third of a grade, calves from Angus x Hereford dams had significantly higher ($P<0.01$) weaning grades than calves from Hereford or Hereford x (Brahman x Hereford) dams. These findings are in agreement with those reported by McCormick and Southwell *(25)*, Damon *et al. (8)*, Rollins *et al. (31)*, and Turner *et al. (35)*.

The least-squares means for post-weaning performance of steers, Table 11, show no significant differences among group means for total gain or average daily gain during the pasture period. A preliminary analysis indicated no significant differences among group means for age of calf at start of pasture period or number of days in the pasture period, Appendix Table 10. However, the feeding program during this period was designed for moderate growth, and absence of a high level of nutrition may have prevented the expression of full growth potential. During the feedlot period, steers from Hereford and those from

TABLE 11. LEAST-SQUARES MEANS[1] OF STEER POST-WEANING TRAITS, PERIOD V

Breeding of calf	Number	Pasture period			Feedlot period		
		Initial weight[2]	Final weight	ADG	Final weight	ADG	Final WDA
		Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
H x H	47	498	636	1.46	980	2.40a	1.96b
A x (A x H)	19	535	669	1.33	1003	2.33ab	1.97b
H x (A x H)	30	561	684	1.35	1024	2.37a	2.07a
H x H (B x H)	60	520	671	1.50	992	2.25b	1.97b

[1] Means followed by different letters differ at $P<0.05$.
[2] Unadjusted weaning weight.

Angus x Hereford dams mated to Hereford bulls gained significantly ($P<0.05$) faster than steers from Hereford x (Brahman x Hereford) dams. No significant differences were found between average daily gain of Angus sired steers from Angus x Hereford dams and those from Hereford x (Brahman x Hereford) dams. Even though no significant differences were found among final feedlot weights, the Hereford sired steers from Angus x Hereford dams had a significantly ($P<0.05$) higher weight per day of age than any other group of steers. At time of slaughter, steers from Angus x Hereford dams by Hereford bulls were not only the heaviest but also the youngest, Appendix Table 9. These results show that the greatest differences in growth rate among the groups occurred during the pre-weaning period and this resulted in the differences in final feedlot weights. The differences in post-weaning gains indicate a compensatory gain for the straightbred Hereford calves. They gained slower from birth to weaning and made the most total gain from weaning to slaughter. These findings are in general agreement with Kincaid *(21)* who showed that crossbreds were 4 per cent heavier than straightbreds at 15 months of age and with Gregory *et al. (18)* that heterosis for feedlot gain was low.

Dressing percentage for the 7/8 Hereford-1/8 Brahman steers was significantly higher ($P<0.05$) than for any other group, Table 12. Both groups of steers from Angus x Hereford dams had significantly higher ($P<0.05$) dressing percentages and chilled carcass weights than those from the straightbred Herefords. No significant difference was found in dressing percentage between the two groups from Angus x Hereford dams. Dressing

TABLE 12. LEAST-SQUARES MEANS[1] OF STEER CARCASS CHARACTERISTICS, PERIOD V

Breeding of calf	Chilled carcass weight	Dressing percentage	Carcass WDA	Rib fat	Ribeye area	Quality grade[2]	Tenderness score[3]
	Lb.	*Pct.*	*Lb.*	*Lb.*	*Sq. in.*		
H x H	553c	56.4c	1.13	0.45b	10.73	11.1b	18.59b
A x (A x H)	577b	57.5b	1.12	0.58a	10.88	12.7a	17.50a
H x (A x H)	586a	57.2b	1.16	0.55a	10.83	11.5b	17.34a
H x H (B x H)	577b	58.2a	1.13	0.48b	11.00	10.6c	19.81c

[1] Means followed by different letters differ at $P<0.05$.
[2] Grade code: 10 = average Good; 11 = high Good; 12 = low Choice, etc.
[3] Tenderness determined by Warner-Bratzler shear (lower scores = more tenderness).

percentage and carcass weight were lowest ($P<0.05$) for straightbred Herefords.

Carcasses of steers from Angus x Hereford dams had significantly more rib fat ($P<0.01$) than carcasses of steers from the other groups of cows. These results agree with those of Damon *et al. (9),* Carpenter *et al. (6),* and Gregory *et al. (18).*

The average quality carcass grades were 12.7, 11.5, 11.1, and 10.6 for the ¾ Angus-¼ Hereford, ¾ Hereford-¼ Angus, straight Hereford, and ⅞ Hereford-⅛ Brahman, respectively. Only the Hereford and the ¾ Hereford-¼ Angus carcasses did not differ significantly. These differences in quality grades are similar to those reported by Damon *et al. (9),* Gregory *et al. (17, 18),* and Vogt *et al. (36),* but greater than reported by Phillips *et al. (28),* Gerlaugh *et al. (13),* Godbey *et al. (14),* and Gaines *et al. (12).*

Carcasses from steers with Angus breeding were most tender. They differed significantly ($P<0.05$) from the straightbred Herefords and at the $P<0.01$ level from the ⅞ Hereford-⅛ Brahman carcasses. No significant differences were found for carcass weight per day of age or ribeye area among the various breed groups of steers.

SUMMARY

From 1950 to 1966, crossbreeding studies involving Angus, Brahman, Hereford, and Shorthorn were conducted at the Black Belt Substation. The following results were obtained:

(1) Crossbred cows producing three-breed calves dropped and weaned a higher percentage of calves than straightbred cows producing two-breed calves.

(2) Crossbred cows producing backcross calves dropped and weaned a higher percentage of calves than straightbred cows producing either straightbred or two-breed calves.

(3) Straightbred Hereford calves were as heavy or heavier at birth than other calves.

(4) Three-breed calves were heavier at birth than were two-breed calves.

(5) Backcross calves were heavier at 250 days of age than were either the two-breed or straightbred Hereford calves.

(6) Three-breed calves were heavier at 250 days of age than two-breed calves.

(7) Differences in slaughter grade at weaning were small (one-third of a grade).

(8) Differences in post-weaning rate of gain were small. However, straightbred Hereford calves gained significantly faster than part-Brahman calves.

(9) The ¾ Hereford-¼ Angus steers had a significantly higher final weight per day of age than the other groups.

(10) Backcross calves produced heavier carcasses than straightbred Herefords.

(11) Carcasses from steers with Angus breeding had more rib fat, graded higher, and were more tender than those from the other breed groups.

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APPENDIX

APPENDIX TABLE 1. COMPOSITION OF RATION FED DURING POST-WEANING PERFORMANCE TEST

Ingredient	Content
	Per cent
Ground snapped corn	50.0
Ground johnsongrass hay	26.5
Cottonseed meal	12.5
Molasses	10.0
Salt	1.0

APPENDIX TABLE 2. LEAST-SQUARES CONSTANTS FOR AGE OF DAM AND REGRESSIONS ON DATE OF BIRTH FOR 250-DAY WEANING WEIGHTS

Age of dam, years	Number	250-day weight
2	64	−4.295
3	124	−28.367
4	128	−8.607
5	140	−0.556
6	145	0.106
7	129	15.031
8	107	5.928
9	73	−0.881
10	44	11.231
11	31	10.830
12 and older	41	−0.420
Regression on date of birth:		
Linear		0.68312078
Quadratic		0.00356768
Cubic		−0.00003460
AVERAGE		492.67

APPENDIX TABLE 3. MEAN SQUARES OF PRE-WEANING TRAITS, PERIOD I

Source of variation	d.f.	Birth weight	250-day ADG	250-day weight
Year	5	188	0.334**	23534**
Sex	1	39	0.400**	27390**
Breed	1	196	1.018**	70891**
Year x sex	5	87	0.031	2634
Year x breed	5	38	0.029	2017
Sex x breed	1	19	0.020	1492
Regression on date of birth:				
Linear	1	811**	1.737**	127389**
Quadratic	1	237	0.023	2800
Cubic	1	503**	0.049	5888
Error	157	68	0.034	2446

** $P<0.01$.

APPENDIX TABLE 4. MEAN SQUARES OF PRE-WEANING TRAITS, PERIOD II

Source of variation	d.f.	Birth weight	250-day ADG	250-day weight
Year	3	224*	0.266**	18729**
Sex	1	8	0.529**	34203**
Breed	2	160	0.451**	30766**
Year x sex	3	84	0.036	2701
Year x breed	6	25	0.037	2416
Sex x breed	2	178	0.015	1385
Regression on date of birth:				
Linear	1	1221**	2.219**	165156**
Quadratic	1	355**	0.003	959
Cubic	1	601**	0.040	5424
Error	183	64	0.034	2401

* $P<0.05$.
** $P<0.01$.

APPENDIX TABLE 5. MEAN SQUARES OF PRE-WEANING TRAITS, PERIOD III

Source of variation	d.f.	Birth weight	250-day ADG	250-day weight
Year	3	156	0.290**	20634**
Sex	1	428**	0.757**	55822**
Breed	2	312**	0.036	1099
Year x sex	3	77	0.041	3370
Year x breed	6	17	0.048	3066
Sex x breed	2	83	0.095	5941
Regression on date of birth:				
Linear	1	862**	0.826**	66054**
Quadratic	1	79	0.042	3681
Cubic	1	215	0.174*	14255*
Error	163	64	0.035	2481

* $P<0.05$.
** $P<0.01$.

APPENDIX TABLE 6. MEAN SQUARES OF PRE-WEANING TRAITS, PERIOD IV

Source of variation	d.f.	Birth weight	250-day ADG	250-day weight	Weaning score[1]
Year	4	392**	0.316**	24843**	(3) 38.7
Sex	1	775**	1.060**	80467**	(1) 5.2
Breed	2	141	0.123*	6158	(2) 14.3
Year x sex	4	111	0.045	2839	(3) 7.4
Year x breed	8	195**	0.078	6009**	(6) 6.5
Sex x breed	2	55	0.035	1672	(2) 0.3
Regression on date of birth:					
Linear	1	1032**	1.308**	101481**	
Quadratic	1	170	0.217**	10594*	
Cubic	1	125	1.004**	57096**	
Error	196	60	0.034	2297	(152) 2.4

* $P<0.05$.
** $P<0.01$.
[1] Weaning scores were not obtained the first year. Degrees of freedom are given in parenthesis.

APPENDIX TABLE 7. MEAN SQUARES OF PRE-WEANING TRAITS, PERIOD V

Source of variation	d.f.	Birth weight	250-day ADG	250-day weight	Weaning score
Year	7	178*	0.232**	16272**	58.6**
Sex	1	383**	1.180**	84460**	10.7**
Breed	3	56	0.632**	36734**	22.1**
Year x sex	7	38	0.048	3198	2.9
Year x breed	20	28	0.043	2519	1.5
Sex x breed	3	80	0.023	2204	0.3
Regression on date of birth:					
Linear	1	7	0.755**	48381**	
Quadratic	1	105	0.050	2141	
Cubic	1	339*	0.003	8	
Error	351	68	0.031	2193	1.7

* $P<0.05$.
** $P<0.01$.

APPENDIX TABLE 8. MEAN SQUARES FOR STEER PERFORMANCE ON PASTURE, PERIOD V

Source of variation	d.f.	Initial age	Days in period	ADG
Year	6	1111**	3508**	1.107
Breed	3	122	378	0.168
Year x breed	17	143	706	0.111
Error	129	140	484	0.117

** $P<0.01$.

APPENDIX TABLE 9. MEAN SQUARES OF STEER CARCASS CHARACTERISTICS, PERIOD V

Source of variation	d.f.	Carcass weight	Carcass WDA	Rib fat	Ribeye area	Quality grade	Tenderness score[1]
Year	6	3382**	0.024**	0.270**	4.95**	9.30**	(4) 11.10
Breed	3	2331**	0.009	0.089**	1.65	16.90**	(3) 39.67**
Year x breed	17	307	0.004	0.025	0.91	1.38	(11) 19.44
Regression on weight	1	239783**	0.560**	0.110**	24.74**	4.13	(1) 35.73
Error	128	353	0.004	0.019	0.85	0.87	(11) 11.81

* $P<0.05$.
** $P<0.01$.
[1] Tenderness scores obtained only during 1962-66. Degrees of freedom are given in parenthesis.

APPENDIX TABLE 10. LEAST-SQUARES MEANS FOR POST-WEANING PERFORMANCE, PERIOD V

Breed group	Pasture period			Feedlot period		
	Initial age	Days in period	Pasture gain	Days in period	Feedlot gain	Age at slaughter
	Days		*Lb.*		*Lb.*	*Days*
H x H	262	95	138	144	344	501
A x (A x H)	266	101	134	144	334	511
H x (A x H)	260	91	123	144	340	495
H x H (B x H)	263	99	151	144	321	506

Methods of Analysis

The following linear model was used for each analysis:

$$Y_{ijkl} = \mu + Y_i + S_j + B_k + YS_{ij} + YB_{ik} + SB_{jk} + b_1BD + b_2BD^2 + b_3BD^3 + E_{ijkl}$$

where:

μ = the overall mean for the Y_{ijkl} when equal frequencies exist in each of the subclasses.
Y_i = the effect of the i-th year.
S_j = the effect of the j-th sex of calf.
B_k = the effect of the k-th breed of calf.
$YS_{(ij)}$ = the effect of the interaction of the i-th year and the j-th sex of calf.
$YB_{(ik)}$ = the effect of the interaction of the i-th year and the k-th breed of calf.
$SB_{(jk)}$ = the effect of the interaction of the j-th sex of calf and the k-th breed of calf.
b_1 = linear regression of the dependent variable (Y) on the independent variable (BD), with all discrete variables held constant.
b_2 = quadratic regression of the dependent variable (Y) on the independent variable (BD), with all discrete variables held constant.
b_3 = cubic regression of the dependent variable (Y) on the independent variable (BD), with all discrete variables held constant.
BD = the date of birth of calf, day 1 on August 1 for each calving season.
E_{ijkl} = the random errors.

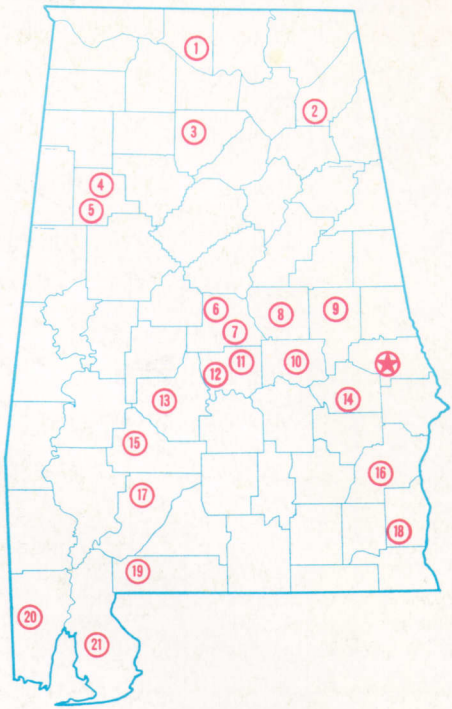
Least-squares analyses for carcass characteristics of steers from Period V were made using the following linear model:

$$Y_{ijk} = \mu + Y_i + B_j + YB_{(ij)} + b\ (xi\text{-}\bar{x}) + E_{ijk}$$

μ = the overall mean for the Y_{ijk} when equal frequencies exist in each of the subclasses.
Y_i = the effect of the i-th year.
B_j = the effect of the j-th breed of calf.
$YB_{(ij)}$ = the effect of the interaction of the i-th year and the j-th breed of calf.
b = linear regression of the dependent variable (Y_i) on the carcass weight (xi).
E_{ijk} = the random errors.

AGRICULTURAL EXPERIMENT STATION SYSTEM OF ALABAMA'S LAND-GRANT UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Thorsby Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. Tuskegee Experiment Field, Tuskegee.
15. Lower Coastal Plain Substation, Camden.
16. Forestry Unit, Barbour County.
17. Monroeville Experiment Field, Monroeville.
18. Wiregrass Substation, Headland.
19. Brewton Experiment Field, Brewton.
20. Ornamental Horticulture Field Station, Spring Hill.
21. Gulf Coast Substation, Fairhope.