HETEROSIS AND ADDITIVE BREED EFFECTS ON FEEDLOT AND CARCASS TRAITS FROM CROSSING ANGUS AND BROWN SWISS

By

TIMOTHY THAD MARSHALL

A DISSERTATION SUBMITTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1986

ACKNOWLEDGEMENTS

I owe special recognition and appreciation to Don Hargrove for his guidance as chairman of my supervisory committee, and for understanding my personal and professional goals. He and the other members of my committee (Don Wakeman, Bill Kunkle, Jimmy Cheek, Dwain Johnson) were interested enough in my pursuit of particular goals to guide me in the direction necessary to reach those goals most effectively.

I thank the cattlemen and 4-H and FFA members of Florida for their support and appreciation while I worked to serve them. Much appreciation is due my wife, Robin, and family. Without their encouragement, I would never have finished this degree.

I owe much to my parents, Thad and Lavada Marshall. Because of their ability to mold a child into a man, I am a hard working, honest person who cares for the people I serve.

Most of all, I praise God for blessing me with the opportunity to live in a free country, work in an area I choose, and worship in the way I believe.

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Timothy Thad Marshall

May 1986

Chairman: Don D. Hargrove
Major Department: Animal Science

A total of 132 steers, produced over a two-year period in a diallele crossbreeding program in which Angus (A), Brown Swiss (BS), and A x BS reciprocal F_1 crossbred cows were bred to bulls of the same three breed-types, were group-fed by breed-type to about 1 cm outside fat. The mathematical model used to determine main and interaction effects included breed of sire, breed of dam, year, and all two-way interactions, plus initial feedlot age and outside fat as covariates. Maternal and individual components of heterosis and additive breed effects were estimated.

Additive effects for the Angus breed were expressed as deviations from the Brown Swiss. Maternal additive effects of the Angus breed on initial weight, slaughter weight, weight per day of age, warm carcass weight, and warm carcass weight per day of age were significant and negative. Individual additive effects for the Angus

were negative and significant for all feedlot traits except average daily gain, and were significant for all carcass traits except ribeye area per 100 kg warm carcass and percentage of kidney, pelvic and heart fat.

Maternal heterosis effects were significant and in the desirable direction only for initial feedlot weight ($P<.05$), slaughter age ($P<.10$), and days on feed ($P<.01$). Individual heterosis effects were significant only for carcass maturity (-5.5 of a score) and marbling (.95 of a degree).

Angus-sired steers had lighter initial and slaughter weights and weight per day of age than those sired by Brown Swiss bulls. Angus-sired steers were also younger at slaughter, required fewer days on feed, and consumed less dry matter than Brown Swiss-sired steers. Angus-sired steers also produced younger, lighter-weight carcasses with smaller ribeyes, less weight per day of age, more marbling, lower cutability, and with higher tenderness ratings. Steers sired by F_1 bulls were intermediate to the parent breeds in the above traits, but did not differ significantly from Angus-sired steers for initial weight, weight per day of age, carcass weight per day of age, or tenderness, or from Brown Swiss-sired steers for yield grade and marbling score. Breed of dam effects were very similar to those for breed of sire. Breed of sire by breed of dam interaction effects were significant for days on feed, slaughter age, marbling score, and Warner-Bratzler shear value.

INTRODUCTION

The agonizing dilemma of the American farmer has become the centerpiece for Academy Award winning movie performances, much as once was the disappearance of the old west. The search for management systems which will enable the continuation of production agriculture must advance without pause. The cause:effect relationship between land use and land value has made extensive beef production systems less practical in a growing number of regions. The beef cow must, therefore, become a more efficient production unit if the beef industry is to survive.

Planned, systematic crossbreeding is a well documented tool, useful for increasing production in the beef business. Possibly more important than the heterosis obtained from crossbreeding is the degree to which the breeds being crossed complement each other. Because of higher milk production of dairy x beef crossbred females (Rutledge et al., 1971), these females usually wean heavier calves than do straightbred beef females. Nelson et al. (1982) found that Brown Swiss x Hereford cows weaned heavier calves and had a higher weaning rate than did Angus x Hereford, Charolais x Hereford, and straightbred Hereford cows. These cattle were producing in a midwestern environment, not one comparable to that in which commercial cattle are produced in Florida.

The objectives of this study were to determine the heterosis and additive breed effects for feedlot performance and carcass characteristics resulting from a diallele crossbreeding system involving the Angus and Brown Swiss breeds.

LITERATURE REVIEW

The degree of success of a crossbreeding system depends mainly on 1) the level of performance in economically important traits of the breeds selected and 2) the specific combining ability of those breeds. Because of higher milk production of dairy x beef crossbred females (Rutledge et al., 1971), they generally wean heavier calves than do beef females. Both van Dijk (1983) and Nelson et al. (1982) reported that Brown Swiss x British beef crossbred females weaned heavier calves and had higher weaning rates than did straightbred British beef females, resulting in more kilograms of calf weaned per cow exposed. The dairy x beef crossbred cow can be a profitable unit in some cow-calf management systems.

Although the potential for dairy breeding in beef production has long been pondered, few studies have been implemented to evaluate the effects of complementarity and heterosis in dairy x beef crosses. Most data collected on this topic have been on maternal and pre-weaning calf performances. Since many workers have compared beef and dairy breeds in terminal crossbreeding studies, these data will be reviewed to enhance the understanding of postweaning performance and carcass characteristics of dairy breeds.

Comparative Feedlot Performance, Carcass Characteristics and Palatability of Dairy and Beef Steers

Feedlot Performance

Before comparisons in feedlot performance can be made, one must determine to what endpoint the cattle will be fed (weight, age, or composition constant). The endpoint used will cause the results to differ significantly for most parameters.

Cartwright (1982) stated that rate of gain of dairy steers can be expected to be similar to that of steers from beef breeds of similar mature size. This concurs with results reported by Cole et al. (1963) and Martin (1971). In contrast, Cundiff et al. (1981) reported that Brown Swiss crossbred calves gained at slightly slower rates than did calves sired by bulls of the large Continental beef breeds. However, these calves gained at significantly faster rates than did calves sired by the smaller British-breed bulls. Similarly, Hentges et al. (1973) reported significantly faster gains for Brown Swiss-sired calves than for Hereford, Hereford x Angus, and Holstein crossbred calves. Similar results were reported by Young et al. (1978), Cole et al. (1963), and Adams et al. (1973). Henderson (1969) reviewed and summarized 19 trials comparing Holstein and beef steers, and reported faster gains for Holstein steers than for beef steers in all trials. These differences ranged from a low of .02 to a high of .5 pound per day.

It is difficult to derive meaningful inferences when comparing differences in feed efficiency among breeds of cattle fed for equal lengths of time or fed to equal weights. When Brown Swiss or

Holstein steers were compared to steers of the British beef breeds under these feeding criteria, dairy steers tended to be more efficient in converting feed to gain (Hentges et al., 1973; Cundiff et al., 1981; Cole et al., 1963). A review of 19 studies (Henderson, 1969) showed that beef and Holstein steers were equally efficient in converting feed into gain (8.16 versus 8.19 lb feed/lb gain, respectively). However, the results were not consistent between experiments. The Holstein steers were more efficient in three of the studies and less efficient in seven. Henderson also reported a significant correlation between rate of gain and efficiency of feed utilization when computed within breed; however, this correlation did not hold true when calculated from combined data on beef and Holstein steers.

Hentges et al. (1973) reported that Brown Swiss-sired steers consumed more feed than steers of beef breeds. Since high levels of milk production require a high level of feed intake, dairy breeds have indirectly been selected for a high level of feed intake and, hence, large gastrointestinal capacity. Henderson (1969) reported that daily feed intake, expressed as a percentage of body weight, was higher for Holstein steers than for beef steers in all but one of the 19 studies reviewed. The respective averages were 2.6 and 2.4%. Dean et al. (1976a) reported similar results for Holstein and Hereford steers.

Few comparisons of feedlot performance of beef and dairy steers have been made when the two types were fed to comparable carcass composition endpoints. Dean et al. (1976a) fed calves that were 0, 25, and 50% Holstein breeding to a common slaughter grade. The 50%

Holstein steers gained .13 kg and .08 kg less per day than did the 0 and 25% Holstein steers, respectively.

When large dairy breeds (Holstein and Brown Swiss) were compared to British beef breeds at comparable gains or fatness, the dairy breeds were 10-25% lower in energetic efficiency (Garrett, 1971; Newland et al., 1979). Cundiff et al. (1981) reported that, when breeds of varying types were fed to a constant fat trim, Brown Swiss-sired calves were similar in feed efficiency to those sired by bulls of the Continental beef breeds and less efficient than steers sired by bulls of the British beef breeds. In addition, they reported that the larger-framed, later-maturing steers required longer feeding periods to reach the same fatness endpoint. This resulted in Brown Swiss steers using a higher percentage of their consumed feed for body maintenance and less for growth, when compared to the smaller steers sired by British beef bulls. Garrett (1971) concluded that the difference in feed efficiency between dairy and beef steers seemed to be due to the more efficient fat deposition (energy storage) of beef steers and the higher maintenance requirement per unit of body weight of the dairy steers.

Carcass Characteristics

As with feedlot performance, carcass characteristics are affected by the slaughter endpoint to which steers are fed. Therefore, the data will be reviewed according to endpoint used (weight or age vs. fatness).

Henderson (1969), in a review of 19 studies, reported that

Holstein steers had from 2.5 to 4.0% lower dressing percentage than did beef steers. Branaman et al. (1962), Wellington (1971), and Koch et al. (1982) reported a 3 to 4% reduction in dressing percentage for dairy steers compared to beef steers. In contrasts to these reports, higher dressing percentages were reported for dairy steers by Cole et al. (1963), Judge et al. (1965), Urick et al. (1974), and Bertrand et al. (1983). Due to the fact that dairy steers have a larger gastrointestinal tract relative to body weight than do beef steers, it would be expected that they would have a lower dressing percentage (Henderson, 1969).

Dressing percentage is affected by degree of fatness. When dairy and beef steers were compared at a constant age or weight, dairy steers had less fat over the ribeye (FOE) and a higher cutability (Cole et al., 1963; Young et al., 1978; Willham, 1973; Ramsey et al., 1963; Judge et al., 1965; Urick et al., 1974; Koch et al., 1982; Henderson, 1969; Wellington, 1971; Bertrand et al., 1983). Kempster et al. (1976) reported that dairy breeds tended to deposit higher proportions of their fat internally and a lower proportion as subcutaneous fat. Although Cole et al. (1963), Wellington (1971), and Adams et al. (1973) reported higher kidney, pelvic and heart fat (KPH) percentages for dairy steers, Henderson (1969) reported a tendency for beef steers to have a higher KPH percentage. Young et al. (1978) also reported that Holstein-sired calves produced carcasses with a lower percentage of KPH than calves sired by Hereford, Angus, Brahman, and Devon bulls.

Historically, dairy cattle have been thought of as light-muscled. However, the literature shows varied results when ribeye areas (REA) were compared among dairy and beef steers slaughtered at common age or weight endpoints. Urick et al. (1974) reported a larger average REA in carcasses from Brown Swiss x Angus steers than in carcasses from Angus steers. Judge et al. (1965), Cole et al. (1963), and Wellington (1971) reported a larger average REA in British beef carcasses than in Holstein carcasses. Adams et al. (1973) showed no difference in REA/100 kg carcass weight for steers sired by Simmental, Maine-Anjou, Lincoln Red, Brown Swiss, Charolais, Angus and Hereford bulls. However, carcasses from steers sired by Limousin bulls had significantly larger ribeyes relative to weight. Henderson (1969) reported varied results in his review, but most studies indicated that Holsteins tended to have a smaller average REA than British beef steers.

Cole et al. (1963) reported the marbling scores for Holstein, Angus and Hereford steers, slaughtered at 900 pounds or 20 months of age, as Practically Devoid, Modest, and Moderate, respectively. Differences in marbling scores were varied in the 19 studies reviewed by Henderson (1969). However, since dairy steers were slaughtered with an average of .39 in less FOE than beef steers, lower marbling scores were expected in the dairy steers. Ramsey et al. (1963), Branaman et al. (1962), Judge et al. (1965), and Ziegler et al. (1971) reported lower average marbling scores in carcasses of Holstein steers than in carcasses of beef steers. In addition, Wellington (1971) reported that carcasses from Holstein steers averaged one marbling score lower than the Angus carcasses; however, the average score for both breeds was within the Choice quality grade. Willham (1973) reported no difference in marbling score between Brown Swiss crossbred and beef steer carcasses. Similarly, Adams et al. (1973) reported no marbling differences between Brown Swiss and Angus carcasses.

Few differences were reported among carcasses of Brown Swiss crossbreds, Holstein crossbreds, Angus x Hereford crossbreds, and Hereford steers when all were fed to a Choice quality grade (Hentges et al., 1973). Dean et al. (1976b) reported that there were increases in length of feeding period, carcass weight, marbling score, and REA as the Holstein breeding increased from 0 to 25 and to 50%, when the steers were fed to a subjectively estimated constant fatness. There were, however, corresponding decreases in FOE and REA/100 kg carcass weight as percentage of Holstein breeding increased. There was no effect of percentage Holstein breeding on yield grade.

When dairy and beef steers are fed to the same carcass fatness, there are some important differences that remain. These differences, summarized in terms of the deviation of dairy breeds from British beef breeds, are: 1) lower dressing percentage due to a larger gastrointestinal tract and greater fill; 2) equal fat deposition over the loin but less external fat and more internal fat (KPH) deposition; and 3) lean distribution indicating a) little difference in ratios of weight of muscles or cuts, b) lower ratio of muscle to bone, and c) ribeye tends to taper at distal end, reducing acceptable steaks that can be cut from the loin (Henderson, 1969).

Palatability

Data reported in the literature would suggest little effect of dairy breeding on palatability when cattle are fed to any endpoint (fatness, weight or age), if they are fed for at least 180 days. Branaman et al. (1962), Judge et al. (1965), Urick et al. (1974), and Koch et al. (1982) reported no significant differences in Warner-Bratzler shear values (WBS) or taste panel scores due to breed type. Ziegler et al. (1971) showed no significant differences in WBS between Holstein, beef and Holstein x beef crossbred steers. However, there was a tendency for Holstein steers to be less tender than steers of the British breeds and more tender than Charolais steers. Ramsey et al. (1963) reported that steaks from Holstein steers were significantly more tender than those from Brahman steers and tended to be less tender than those from Hereford and Santa Gertrudis steers.

Heterosis and Additive Breed Effects on Feedlot Performance and Carcass Characteristics

Beef production parameters are composites of the additive breed and heterotic effects exerted upon the calf directly and by maternal environment. Thus, to utilize information from crossbreeding studies in the design of optimal crossbreeding systems, one must be able to partition the overall effects into those due to each breed, both direct and maternal, and those due to heterosis, both direct and through the maternal ability of the crossbred dam.

Maternal Components

Alenda et al. (1980) reported no significant maternal breed effect on daily gain, ribeye area, or ribeye area per 100 kg of carcass for Angus, when comparing Angus, Hereford and Charolais. Their results included negative maternal heterosis estimates for ribeye area and ribeye area per 100 kg of carcass from crossing Angus with Hereford and Charolais, all of which were significant except for ribeye area in the Angus x Charolais crosses.

Peacock et al. (1982) mated Angus (A), Brahman (B), and Charolais (C) bulls in all combinations to A, B, C, and reciprocal firstcross AB, AC, and BC females. They reported no significant maternal breed effect on average daily gain, carcass weight, fat over the ribeye, ribeye area per 100 kg of carcass, tenderness, or quality grade. The steers were slaughtered after a constant time on feed. Significant maternal heterosis estimates were reported for carcass weight and fat over the ribeye (17 kg and .2 cm) when Angus and Brahman were crossed. The only significant maternal heterosis estimate reported in the Angus x Charolais crosses was for carcass weight (8.6 kg).

Gregory et al. (1978a,b) reported estimates of maternal breed effects for Angus and Brown Swiss. The Brown Swiss breed showed a significantly greater maternal additive effect for weight at 200, 312, and 424 days of age than did the Angus, with the 424 day advantage being 45.6 kg. There was no significant difference in maternal breed effect for average daily gain. The Brown Swiss differed significantly from the Angus by exhibiting a higher maternal breed effect for carcass weight (34.5 kg) and fat over the ribeye (.15 cm), and a lower maternal breed effect for cutability (1%) when the data were adjusted to an age constant basis. However, the maternal breed effect was not significant when the data were adjusted for the effects of weight on carcass traits.

No maternal heterosis estimates were found for crossbreeding systems using Angus and Brown Swiss.

Individual Components

In a study reported by Gregory et al. (1978a,b), steers of the Red Poll, Brown Swiss, Angus and Hereford breeds and all 12 reciprocal two-breed crosses were produced in a four-breed diallele crossing program. These steers were fed to an average age of 14 months. Average effects of heterosis for all breed crosses were significant (P<.01) for weights at weaning (12.7 kg), 10 months of age (15.6 kg), and slaughter (15.2 kg). The Brown Swiss x Angus crosses expressed significant heterosis at weaning (12 kg), 10 months of age (13 kg), and slaughter (24 kg). In all crosses except the Brown Swiss x Angus, heterosis for average daily gain decreased with increasing age of calf. However, the Brown Swiss x Angus crossbred steers showed a large increase in heterotic effect on average daily gain from 10 months of age to slaughter. The specific combining ability for growth traits was highest in Brown Swiss, when compared to Red Poll, Angus and Hereford in all possible two-breed crosses. Hentges et al. (1973) reported significant heterosis for appetite (intake) of Brown Swiss crossbred steers.

Gregory et al. (1978b) reported direct additive breed effects for weaning weight, 10-month weight, and 14-month or slaughter weight, respectively, of 12.3 kg, 21.9 kg, 36.9 kg for Brown Swiss and 3.5 kg, 8.2 kg, 7.5 kg for Angus. These authors reported average daily gains during two time periods, 200 to 312 days of age and 312 to 424 days of age. The direct additive breed effects on average daily gains during the two periods were 85 g and 134 g for Brown Swiss and 41 g and -6 g for Angus. The ranking of breeds for direct additive breed effects for growth traits was, in descending order, Brown Swiss, Angus, Hereford, and Red Poll.

Gregory et al. (1978a) evaluated carcass data on 537 steers from a four-breed diallele crossing design that included the Red Poll, Brown Swiss, Angus and Hereford breeds. They determined the effects of heterosis and direct additive gene action on carcass characteristics. The only significant heterotic effect observed for the Brown Swiss x Angus crossbred steers was for carcass weight on an age constant basis (13.1 kg). On a weight constant basis the Brown Swiss x Angus crossbreds showed no significant heterosis for carcass traits. On an age constant basis, these workers reported that carcasses from the Brown Swiss breed differed significantly from Angus, Hereford, and Red Poll in direct additive breed effects for slaughter weight, carcass weight, FOE, REA, cutability, and retail product. The additive breed effects of Brown Swiss on these traits were 35.5 kg, 16.8 kg, -.53 cm, 11.8 cm^2, 4%, and 4.8%, respectively. When compared as a deviation from the average of all purebreds, the additive breed effects for Angus were significantly different from those for the Brown Swiss for fat related traits. These deviations for Angus and Brown Swiss were 1.1 vs .2, -2.5 vs 4.0%, -3.2 vs 4.8%, and 7.0 vs -2.6 g, respectively, for quality grade, cutability, retail product, and fat trim. Compared on a weight constant basis, the results were very similar to those reported for direct additive breed effects on an age constant basis. The Brown Swiss exhibited a significantly different additive breed effect for dressing percentage, FOE, REA, cutability, retail product, and bone than did the Angus (-1.6 vs 0.3%, -.50 vs .36 cm, 8.4 vs -2.3 cm^2, 3.7 vs -2.4 %, 4.6 vs -3.1%, .6 vs -.8 kg for Brown Swiss and Angus, respectively). The direct effects for the Angus breed on marbling score and quality grade were significantly higher than were those for the Brown Swiss.

Bertrand et al. (1983) evaluated carcass data on 371 steers, produced in a four-breed diallel cross design (Angus, Hereford, Holstein, and Brown Swiss). The steers were slaughtered at an average age of 14 months. Significant heterosis effects were exhibited in the Brown Swiss x Angus cross for slaughter weight (32.4 kg), carcass weight (21.6 kg), marbling score (1.7), quality grade (.8), and REA (4.6 cm^2).

MATERIALS AND METHODS

One hundred and thirty-two steers, born in 1979 and 1980 from a diallele crossing program involving Angus, Brown Swiss, and Angus x Brown Swiss F_1 crossbreds (table 1), were weaned at an average age of 210 days and group fed by breed-type, to an estimated outside fat thickness of 1 cm. The diets fed are shown in table 2. In year 1 (1979-80), steers were fed in covered feeding pens at the North Florida Research and Education Center, Quincy, Florida, and in year 2, the steers were fed in open lots at the Beef Research Unit, Gainesville, Florida. Steers had free access to water and a complete mineral mix throughout the feeding period. Steers were injected with 12 ml Tramisol, 1.5 million IU Vitamin A, 225,000 IU Vitamin D, and 25 ml Terramycin at the beginning of the feeding period. At this time, steers were implanted with 36 mg of Ralgro and implanted 62 and 98 days later, in the first and second years respectively, with Synovex-S.

Since steers were group-fed by breed groups, individual feed intake was not measurable. Therefore, total dry matter intake, daily dry matter intake, and feed efficiency data obtained each year were breed group averages. Initial and final feedlot weight were calculated shrunk weights, obtained by decreasing the actual weights by four percent.

TABLE 1. MATING DESIGN AND NUMBER OF STEERS BY BREED TYPE

	Breed of dam			
Breed of sire	Angus	Brown Swiss	F_1(AxBS)[a]	Total
Angus (A)	14	10	17	41
Brown Swiss (BS)	10	13	17	40
F_1(AxBS)[a]	16	16	19	51
TOTAL	40	39	53	132

[a]Reciprocal crosses combined.

TABLE 2. COMPOSITION OF DIETS AND INGREDIENT DRY MATTER

Ingredient	Composition, as fed basis (%)	Ingredient dry matter (%)
<u>1979-80</u>		
Whole shelled corn (IFN 4-02-931)	70	88
Corn silage (IFN 3-08-153)	23	40
Protein supplement (50% protein equivalent)	7	90
<u>1980-81</u>		
High moisture corn (IFN 4-20-770)	71	75
Corn silage (IFN 3-28-250)	23	32
Protein supplement (60% protein equivalent)	6	90

Steers were slaughtered and carcass data collected at the University of Florida Meats Laboratory. Carcass data collected included all USDA Quality and Yield Grade components. Warner-Bratzler shear force was measured on 1.27 cm cores from steaks cut from the short loin. Carcass weight per day of age and ribeye area per 100 kg of carcass were calculated.

Data were analyzed using the General Linear Model Procedures (SAS, 1979). The original mathematical model used included breed of sire, breed of dam, year, and all 2- and 3-factor interactions. The 3-factor interactions were not significant sources of variation and were removed from the final model. Fat over the ribeye was included as a covariate in all models. Initial feedlot age was also used as a covariate, because calves out of Brown Swiss cows were younger than those from other dam breeds.

The procedure providing simultaneous estimates of additive and heterosis effects for both individual and maternal components is based on the assumption that individual and maternal components combine additively, and that heterosis is linear with respect to the percentage of loci where the alleles originate from different breeds (table 3). The mathematical model used to estimate heterosis and additive breed effects for all response variables was:

$$Y_{ij} = \mu + T_i + A_oX_1 + A_mX_2 + H_oX_3 + H_mX_4 + FOE + BAGE + e_{ij}$$

where,

Y_{ij} = observation of the jth steer or jth pen average during the ith year

μ = population mean

T_i = effect due to ith year

A_o and A_m = parital regression coefficients for additive breed effects for offspring (o) and maternal (m) components, respectively

H_o and H_m = partial regression coefficients for heterosis effects for offspring (o) and maternal (m) components, respectively

X_1 and X_2 = measure of breed composition of the calf and its dam, respectively (recorded as the proportion of Angus breeding)

X_3 and X_4 = measure of breed heterozygosis for the calf and its dam, respectively, with values for the F_1 at 1, backcross at .5 and purebred at 0

BAGE = initial feedlot age (covariate)

FOE = fat over ribeye (covariate)

e_{ij} = random error associated with the measurement of the jth calf or jth pen average during the ith year

TABLE 3. COEFFICIENTS FOR INDIVIDUAL AND MATERNAL ADDITIVE EFFECTS, AND HETEROZYGOTIC LOCI FOR VARIOUS BREED GROUPS

	Additive					
	Individual		Maternal		Heterosis	
Breed groups[a] (Sire x Dam)	A[b]	BS	A[c]	BS	Individual[d]	Maternal[e]
A x A	1	0	1	0	0	0
BS x BS	0	1	0	1	0	0
A x BS	.5	.5	0	1	1	0
BS x A	.5	.5	1	0	1	0
BS x ABS	.25	.75	.5	.5	.5	1
A x ABS	.75	.25	.5	.5	.5	1
ABS x ABS	.5	.5	.5	.5	.5	1
ABS x A	.75	.25	1	0	.5	0
ABS x BS	.25	.75	0	1	.5	0

[a]A = Angus, BS = Brown Swiss, ABS = Angus x Brown Swiss F_1 reciprocal crossbreds.
[b]Represents X_1 values in the model.
[c]Represents X_2 values in the model.
[d]Represents X_3 values in the model.
[e]Represents X_4 values in the model.

RESULTS AND DISCUSSION

Feedlot Performance

Crossbreeding of cattle for commercial beef production, as well as for breed development and upgrading programs, has become widespread in the past 20 years. Determination of genetic and maternal effects attributable to each breed and breed combination should provide producers added information to improve the efficacy of crossbreeding systems.

Additive Breed Effects

The Angus and Brown Swiss breeds are very different in mature size and milk production; therefore, significantly different maternal additive effects for postweaning growth traits might be expected. Expressed as a deviation from the Brown Swiss breed, the maternal additive effects for the Angus breed on initial feedlot weight ($P<.001$), final feedlot weight ($P<.01$), and weight per day of age ($P<.01$) were negative (table 4). These results support those reported by Gregory et al. (1978b). Although not significantly different, the desirable maternal additive effect for the Angus breed on feed efficiency may be sufficiently large to be of economic importance (table 4). Had individual feed intake been measured, adequate degrees of freedom would have existed to increase the

TABLE 4. ESTIMATES FOR MATERNAL AND INDIVIDUAL ADDITIVE, AND MATERNAL AND INDIVIDUAL HETEROSIS EFFECTS ON FEEDLOT PERFORMANCE

Components[a]	Initial feedlot weight	Final feedlot weight	Slaughter age	Weight per day of age	Days on feed	Total DM intake	Average daily DM intake	Feed per kg gain	Average daily gain
	Effects in units of measure								
	kg	kg	d	kg	d	kg	kg	kg	kg
Maternal additive	-30.0***	-25.7+	1.8	-.058+	1.8	81	.09	-.51	.02
Individual additive	-30.8*	-128.0***	-68.0***	-.134**	-68.0***	-1399**	-2.12+	-1.88+	-.03
Maternal heterosis	18.7*	4.6	-7.8+	.038	-7.8+	-12	.19	.17	-.01
Individual heterosis	-11.2	.7	-.3	.010	-.3	-85	-.32	-.37	.07
	Heterosis expressed as percent deviation from midparent mean								
Maternal heterosis	7.7*	.9	-1.7+	3.5	-5.9+	-.7	2.2	2.7	-.7
Individual heterosis	-4.6	.1	0	.9	-.2	-5.1	-3.7	-5.8	5.1

[a]Additive effects are for Angus and are expressed as deviatioos from Brown Swiss.
+P<.1
*P<.05
**P<.01
***P<.001

sensitivity of the model, and the observed effect might have been significant. These data concur with those reported by Gregory et al. (1978b), in that they did not show any significant difference in the maternal additive effects of the Angus and Brown Swiss breeds on average daily gain.

The individual component of the additive effect for the Angus breed was negative for all feedlot traits, and significant for all traits except average daily gain (table 4). These results were not unexpected since the Angus are smaller-framed cattle and would be expected to consume less feed and reach a specified outside fat endpoint quicker than Brown Swiss steers. Gregory et al. (1978b) reported significantly lower additive breed effects for initial weight, slaughter weight, and average daily gain for the Angus than for the Brown Swiss. Similar, but larger, differences were published by Alenda et al. (1980) and Peacock et al. (1982), when comparing the Angus and Charolais breeds.

Heterosis Effects

Traits, in crossbred calves produced by crossbred cows, that are subject to maternal influence, such as weaning weight, are affected by two components of heterosis. These are the individual and maternal components. The crossbred dam contributes the effect due to maternal heterosis. The significant, positive maternal heterosis for initial feedlot weight that was found in this study (table 4) was not unexpected, since the steers were placed in the feedlot a short time after weaning. The only other significant maternal heterosis estimates for feedlot performance traits were for slaughter age and days on feed (table 4). Beginning age was included as a covariate in the mathematical model used to analyze the data, therefore, these two traits are really the same. The negative maternal heterosis estimates for slaughter age (-7.8%) and days on feed (-7.8%) show that the steers produced by Angus x Brown Swiss crossbred dams reached 1 cm outside fat at an earlier average age and after fewer days in the feedlot than the average of those produced by straightbred dams. Olson et al. (1985), working with the same breeding herds, reported that calves from Angus x Brown Swiss crossbred dams were heavier and fatter at weaning than the average of those from Angus and Brown Swiss dams. These steers entered the feedlot immediately after weaning. The steers from crossbred dams, therefore, required a shorter feeding period to reach 1 cm outside fat than the average of the steers from straightbred dams. No maternal heterosis estimates were found for crossbreeding systems using Angus and Brown Swiss. However, Alenda et al. (1980) did not find a significant maternal heterosis estimate for daily gain in Angus and Charolais crosses.

Falconer (1981) stated that heterosis is the recovery from inbreeding depression, and that the traits which suffer most from inbreeding depression are reproduction and survivability. Therefore, little or no heterosis due to the individual component would be expected for most feedlot performance traits. In this study, individual heterosis was not significant for any feedlot performance trait (table 4). However, significant estimates of individual heterosis for initial and slaughter weights were reported by Gregory et al. (1978b) and Bertrand et al. (1983). These authors fed steers from an Angus x Brown Swiss crossbreeding system to an age constant endpoint, rather than a common fat endpoint. Therefore, comparisons with data from this study are indirect and may actually involve the measurements of slightly different traits.

Breed of Sire Effects

Steers sired by Angus bulls had lighter initial ($P<.01$) and final ($P<.02$) feedlot weights, and a lighter weight per day of age ($P<.03$) than those sired by Brown Swiss bulls (table 5). The Angus-sired steers were also younger at slaughter ($P<.0001$) and required thirty-two fewer days ($P<.0001$) in the feedlot to reach 1 cm outside fat. Steers sired by F_1 Angus x Brown Swiss bulls were intermediate to the parent breeds, and were significantly different from the Brown Swiss-sired steers for all of the traits reported above. The F_1 Angus x Brown Swiss-sired steers were different from the Angus-sired steers only for slaughter weight, days on feed, and slaughter age. An advantage in weight at slaughter for the Brown Swiss was also reported by Adams et al. (1973), Gregory et al. (1978b), and Bertrand et al. (1983).

There was no breed of sire effect on average daily gain (table 5). These data concur with those reported by Adams et al. (1973), who slaughtered steers at a constant quality grade. Gregory et al. (1978b), using an age constant slaughter point, did report a significant advantage in daily gain for Brown Swiss-sired steers over those sired by Angus bulls. Since the steers were group-fed by breed, the model for total dry matter intake, daily dry matter intake, and feed to gain ratio had only 17 total degrees of freedom.

TABLE 5. LEAST SQUARES ESTIMATES ± SE FOR FEEDLOT PERFORMANCE BY BREED OF SIRE

Breed of sire	Initial feedlot weight (kg)	Final feedlot weight (kg)	Slaughter age (d)	Weight per day of age (kg)	Days on feed (d)	Total DM intake (kg)	Average daily DM intake (kg)	Feed per kg gain (kg)	Average daily gain (kg)
Angus (A)	231.4 ± 4.4^a	461.7 ± 7.6^a	436.6 ± 1.5^a	$1.061 \pm .017^a$	166.6 ± 1.5^a	1170 ± 117^a	$8.15 \pm .35$	$6.08 \pm .15$	$1.38 \pm .03$
Brown Swiss (BS)	246.4 ± 4.4^b	524.8 ± 7.6^c	469.0 ± 1.5^c	$1.129 \pm .017^b$	198.9 ± 1.5^c	1983 ± 104^c	$9.15 \pm .31$	$6.41 \pm .13$	$1.41 \pm .03$
F_1 (AxBS)[d]	236.6 ± 3.6^a	486.0 ± 6.2^b	452.4 ± 1.3^b	$1.080 \pm .014^a$	182.3 ± 1.3^b	1567 ± 41^b	$8.46 \pm .12$	$6.16 \pm .05$	$1.38 \pm .02$
Significance	$P<.1$	$P<.02$	$P<.0001$	$P<.03$	$P<.0001$	$P<.1$	NS	NS	NS

[a,b,c]Estimates in same column with different letters differ at level of significance shown.
[d]Reciprocal crosses combined.

The only one of these traits affected by breed of sire was total dry matter intake ($P<.1$). However, in all three traits, the Angus-sired steers tended to be lower than those sired by F_1 Angus x Brown Swiss bulls, which, in turn, tended to be lower than those sired by Brown Swiss bulls. There was a definite practical advantage for Angus-sired steers in feed efficiency (8.15 versus 9.15 kg feed per kilogram of gain, respectively, for Angus and Brown Swiss sired steers). Conversely, Adams et al. (1973) showed a tendency for Brown Swiss-sired steers to be more efficient feed converters than Angus-sired steers.

Breed of Dam Effects

Breed of dam significantly affected ($P<.05$) all weight and time related feedlot traits (table 6). The steers from Angus dams were the lightest weight, spent the fewest days in the feedlot and were, therefore, youngest at slaughter. The steers produced by F_1 Angus x Brown Swiss crossbred dams were intermediate to those produced by both straightbred groups of dam. These data concur with those of Gregory et al. (1978b) and Bertrand et al. (1983), who reported significant breed of dam effects for slaughter and initial weights and for slaughter age.

There was no significant breed of dam effect on average daily gain (table 6). This finding is supported by the results reported by Gregory et al. (1978b). Steers from Angus dams consumed less feed per day ($P<.06$) and less total feed during the feeding period ($P<.07$) than those from Brown Swiss and F_1 Angus x Brown Swiss dams. Steers from Angus dams were also more efficient in feed utilization

TABLE 6. LEAST SQUARES ESTIMATES ± SE FOR FEEDLOT PERFORMANCE BY BREED OF DAM

Breed of dam	Initial feedlot weight (kg)	Final feedlot weight (kg)	Slaughter age (d)	Weight per day of age (kg)	Days on feed (d)	Total DM intake (kg)	Average daily DM intake (kg)	Feed per kg gain (kg)	Average daily gain (kg)
Angus (A)	211.8 ± 4.3[a]	445.2 ± 7.4[a]	437.9 ± 1.5[a]	1.021 ± .016[a]	167.9 ± 1.5[a]	1286 ± 53[a]	7.90 ± .15[a]	5.65 ± .07[a]	1.39 ± .02
Brown Swiss (BS)	257.8 ± 4.5[c]	535.0 ± 7.7[c]	469.4 ± 1.6[c]	1.148 ± .017[c]	199.4 ± 1.6[c]	1980 ± 66[c]	9.12 ± .19[b]	6.65 ± .08[b]	1.39 ± .03
F_1 (AxBS)[d]	244.8 ± 3.6[b]	492.4 ± 6.1[b]	450.6 ± 1.2[b]	1.101 ± .014[b]	180.6 ± 1.2[b]	1544 ± 44[b]	8.73 ± .13[b]	6.35 ± .06[b]	1.38 ± .02
Significance	P<.05	P<.0001	P<.0001	P<.05	P<.0001	P<.07	P<.06	P<.02	NS

[a,b,c]Estimates in the same column with different letters differ at level of significance shown.
[d]Reciprocal crosses combined.

(P<.02) than those from F_1 Angus x Brown Swiss and Brown Swiss dams. Steers from F_1 Angus x Brown Swiss dams were intermediate to those produced by the straightbred dams for both measures of dry matter intake, but differed from the steers out of Brown Swiss dams only for total dry matter intake (P<.07).

Breed of Sire by Breed of Dam Interactions

Breed of sire by breed of dam interactions significantly affected days on feed, average daily gain, and slaughter age. Since initial feedlot age was used as a covariate in all mathematical models, any difference in days on feed would result in an equal change in slaughter age (table 7). Within all breed of sire groups, steers from Brown Swiss dams required more days on feed to reach 1 cm outside fat than those from Angus and F_1 Angus x Brown Swiss dams (table 7). Likewise, within breed of dam groups, steers sired by Brown Swiss bulls required a longer feeding period to reach the designated 1 cm outside fat than did those sired by Angus and F_1 Angus x Brown Swiss bulls. However, the variation among breed of dam groups was not consistent among breed of sire groups. Within Angus-sired steers, those from Angus and F_1 Angus x Brown Swiss dams were nearly identical for days on feed, and both groups required about 31 days less time to reach 1 cm outside fat than did those from Brown Swiss dams. Within Brown Swiss-sired steer groups, steers from Angus dams finished after a shorter feeding period than those from F_1 Angus x Brown Swiss dams and the groups required about 20 and 13 days less, respectively, to reach 1 cm outside fat than did steers from Brown Swiss dams.

TABLE 7. LEAST SQUARES ESTIMATES ± SE FOR DAYS ON FEED, FINAL FEEDLOT AGE, AND AVERAGE DAILY GAIN BY BREED OF SIRE AND BREED OF DAM

	Breed of sire		
Breed of dam	Angus (A)	Brown Swiss (BS)	F_1 (AxBS)[a]
	Days on feed (d)		
Angus	156.3 ± 2.6	190.0 ± 2.9	157.4 ± 2.2
Brown Swiss	187.4 ± 2.9	210.1 ± 2.8	200.6 ± 2.3
F_1 (AxBS)[a]	156.0 ± 2.2	196.6 ± 2.2	189.1 ± 2.1
	Final feedlot weight (kg)		
Angus	426.3 ± 2.6	460.0 ± 2.9	427.4 ± 2.2
Brown Swiss	457.4 ± 2.9	480.2 ± 2.8	470.6 ± 2.3
F_1 (AxBS)[a]	426.0 ± 2.2	466.6 ± 2.2	459.1 + 2.1
	Average daily gain (kg)		
Angus	1.32 ± .04	1.39 ± .05	1.46 ± .04
Brown Swiss	1.39 ± .05	1.42 ± .05	1.37 ± .04
F_1 (AxBS)[a]	1.43 ± .04	1.41 ± .04	1.30 ± .03

[a]Reciprocal crosses combined.

The significant breed of sire by breed of dam interaction effects on average daily gain show that the straightbred Brown Swiss steers gained faster than straightbred Angus steers, and that the F_1 Angus x Brown Swiss crossbreds were intermediate to the straightbreds (table 7). The F_2 Angus x Brown Swiss steers, however, had the lowest average daily gain and the steers with one-fourth Brown Swiss breeding had the highest average daily gain of all breed groups.

Carcass Characteristics

Carcass attributes, including meat palatability, of breeds and breed crosses are becoming more important in determining the potential of different crossbreeding systems. Additive effects of the Brown Swiss breed and the heterosis effects obtained from using the Brown Swiss in crossbreeding programs have not been evaluated thoroughly under beef production systems.

Additive Breed Effects

Because of the lower milk production potential of the Angus breed relative to the Brown Swiss, significantly different maternal additive effects for growth related carcass traits would be expected. The maternal additive effects of the Angus breed, expressed as deviations from the Brown Swiss, were negative ($P<.10$) for carcass weight and carcass weight per day of age, but were not significant for any of the other carcass characteristics measured (table 8). Supportive results were published by Gregory et al. (1978a), who reported significant differences in maternal additive effects for the Angus and Brown Swiss breeds on slaughter weight and

TABLE 8. ESTIMATES FOR MATERNAL AND INDIVIDUAL ADDITIVE, AND MATERNAL AND INDIVIDUAL HETEROSIS EFFECTS ON CARCASS TRAITS

Component[a]	Hot carcass weight	Carcass weight per day of age	KPH fat	Ribeye area	Ribeye area per 100 kg carcass	Yield grade	Maturity	Marbling	Warner-Bratzler shear force
				Effects in units of measure					
	kg	kg	%	cm^2	cm^2	grade	score	degree	kg
Maternal additive	-16.9+	-.037+	-.22	- 1.2	.8	- .2	- 1.3	- .38	.7
Individual additive	-76.5***	-.080*	.09	-18.6***	.6	.4*	- 8.8*	1.01*	- 1.6*
Maternal heterosis	5.9	.029	.02	2.6	.2	- .1	1.2	- .19	0
Individual heterosis	.2	.006	.01	- 2.1	- .4	.1	- 5.5*	.95***	.1
			Heterosis expressed as percent deviation from midparent mean						
Maternal heterosis	2.0	4.4	.8	3.5	.8	3.5	2.2	-5.0	0
Individual heterosis	0	.9	.4	- 2.8	- 1.6	3.5	-12.4*	24.9***	2.0

[a]Additive effects are for Angus and are expressed as deviations from Brown Swiss

+P<.1

*P<.05

***P<.001

carcass weight, when steers were slaughtered at an age constant endpoint. These authors, however, found no difference in maternal additive effects of the two breeds for any carcass characteristic when the steers were slaughtered at a weight-constant endpoint.

The individual additive effects of the Angus breed, again expressed as a deviation from the Brown Swiss, were significant for all carcass traits except ribeye area per 100 kg carcass and percentage of kidney, pelvic, and heart fat (table 8). These results indicate that the use of the Angus breed would increase carcass quality grade and tenderness, but would decrease the carcass weight, ribeye area, and cutability if included in a crossbreeding system with Brown Swiss. Results from this study are in agreement with those published by Gregory et al. (1978a).

Heterosis Effects

Maternal heterosis did not significantly affect any carcass trait (table 8). When cattle are slaughtered at a fat constant endpoint, one would not expect carcass traits to be affected greatly by maternal heterosis for two reasons; 1) carcass traits are not normally associated with fitness and therefore would not respond to increase in heterozygosity, and 2) residual effects from a maternal influence should be small after a feeding period of over 150 days. Also, maternal heterosis did not affect feedlot average daily gain or final feedlot weight (table 4); therefore, maternal heterosis should not have significantly affected growth-related carcass traits.

Individual heterosis was significant for only two carcass characteristics, maturity ($P<.05$) and marbling ($P<.001$) (table 8).

The individual heterosis effect on carcass maturity may have little economic importance, since all carcasses were A maturity and the amount of variation was small. The 24.9% individual heterosis estimated for marbling was larger than expected, and contrary to results of Gregory et al. (1978a). However, Bertrand et al. (1983) reported a significant effect of individual heterosis on marbling (.57 of a degree). This was smaller than the .95 of a degree found in this study. This positive effect of individual heterosis on marbling score would be extremely important as long as the value of beef carcasses is affected by marbling score. Individual heterosis estimates for carcass traits related to growth rate were not significant. In contrast, Gregory et al. (1978a) and Bertrand et al. (1983) reported significant heterosis effects on carcass weight and ribeye area in Angus x Brown Swiss crossbreds. However, steers in their studies were compared on an age constant, rather than a fat constant, basis.

Breed of Sire Effects

Breed of sire had a significant effect on all carcass traits except percentage of kidney, pelvic and heart fat and ribeye area per 100 kg of carcass (table 9). When compared to Brown Swiss-sired steers, the steers sired by Angus bulls were younger at slaughter ($P<.001$), had smaller carcasses ($P<.01$), and had lighter carcass weights per day of age ($P<.01$). Since there generally is a positive correlation between ribeye area and carcass weight, the significant advantage in ribeye area for the steers sired by Brown Swiss and F_1 Angus x Brown Swiss crossbred bulls was to be expected. These

TABLE 9. LEAST SQUARES ESTIMATES ± SE FOR CARCASS TRAITS BY BREED OF SIRE AND BREED OF DAM

Breed group	Hot carcass weight	Carcass weight per day of age	KPH fat	Ribeye area	Ribeye area per 100 kg carcass	Yield grade	Maturity[d]	Marbling[e]	Warner-Bratzler shear force
Breed of Sire	kg	kg	%	cm^2	cm^2	grade	score	degree	kg
Angus	289.7 ± 4.7[a]	.646 ± .010[a]	2.5 ± .1	70.1 ± 1.2[a]	25.3 ± .4	3.0 ± .1[a]	40 ± 1[a]	4.29 ± .14[a]	4.3 ± .2[a]
Brown Swiss	318.3 ± 4.7[c]	.686 ± .010[b]	2.4 ± .1	79.1 ± 1.2[c]	24.9 ± .4	2.7 ± .1[b]	45 ± 1[b]	3.76 ± .14[b]	5.1 ± .2[b]
F_1 (AxBS)[f]	297.9 ± 3.9[b]	.663 ± .009[a]	2.5 ± .1	75.3 ± 1.0[b]	25.4 ± .3	2.8 ± .1[b]	42 ± 1[ab]	3.81 ± .11[b]	4.5 ± .2[a]
Significance	P<.01	P<.1	NS	P<.02	NS	P<.09	P<.03	P<.02	P<.02
Breed of Dam									
Angus	270.0 ± 4.6[a]	.621 ± .010[a]	2.3 ± .1	68.7 ± 1.2[a]	25.5 ± .4	2.8 ± .1	39 ± 1[a]	4.05 ± .13	4.7 ± .2
Brown Swiss	326.1 ± 4.8[c]	.700 ± .011[c]	2.5 ± .1	79.7 ± 1.3[c]	24.6 ± .4	2.9 ± .1	45 ± 1[b]	4.00 ± .14	4.7 ± .2
F_1 (AxBS)[f]	300.7 ± 3.8[b]	.673 ± .008[b]	2.5 ± .1	76.1 ± 1.0[b]	25.4 ± .3	2.8 ± .1	43 ± 1[b]	3.81 ± .11	4.6 ± .2
Significance	P<.001	P<.06	NS	P<.04	NS	NS	P<.02	NS	NS

[a,b,c]Estimates in same column with different letters differ at level of significance shown.
[d]All A maturity: 40 = A^{40}
[e]3 = slight, 4 = small
[f]Reciprocal crosses combined.

results concur with those of Urick et al. (1974), Gregory et al. (1978a), Koch et al. (1982), and Bertrand et al. (1983). When ribeye area was expressed on a carcass weight basis, there was no significant difference due to breed of sire. Adams et al. (1973) reported similar results for ribeye area per 100 kg of carcass. Angus-sired steers had carcasses with higher yield grades, indicating lower cutability, than those sired by Brown Swiss bulls. The steers sired by F_1 Angus x Brown Swiss and Brown Swiss bulls did not differ significantly in carcass yield grade. Had estimation of subcutaneous fat thickness in the live animal been more precise in this study (table 10), lower cutability of the carcass from Angus-sired steers might not have been observed.

TABLE 10. LEAST SQUARES ESTIMATES ± SE FOR FAT OVER THE RIBEYE (CM) BY BREED OF SIRE AND BREED OF DAM

	Breed of sire		
Breed of dam	Angus (A)	Brown Swiss (BS)	F_1 (AxBS)[a]
Angus (A)	1.27 ± .09	.99 ± .10	1.04 ± .08
Brown Swiss (BS)	1.22 ± .11	.68 ± .09	.89 ± .08
F_1 (AxBS)	1.28 ± .08	.87 ± .08	1.18 ± .07

[a] Reciprocal crosses combined.

Carcasses from Angus-sired steers had a significantly lower maturity score and a higher degree of marbling than those from steers sired by Brown Swiss bulls. Carcasses from steers sired by F_1 Angus x Brown Swiss bulls were intermediate to those sired by the straightbred bulls for both traits, but were not significantly different from those of either breed group for carcass maturity, or from those of Brown Swiss-sired steers for marbling score. These data differ from those reported by Willham et al. (1970), Adams et al. (1973), and Hentges et al. (1973), but are in agreement with data published by Gregory et al. (1978a), Koch et al. (1982), and Bertrand et al. (1983). However, comparisons among this study and the other studies cited are difficult because the cattle were slaughtered at different endpoints.

The longissimus muscle from Angus-sired and F_1 Angus x Brown Swiss-sired steer carcasses was more tender ($P<.02$) than that from Brown Swiss-sired steers. Urick et al. (1974) reported no significant difference in tenderness from Angus and F_1 Brown Swiss x Angus steer carcasses, but they did show a tendency for the Angus to be more tender.

Breed of Dam Effects

Only those carcass traits related to growth rate, size, and maturity rate were affected by breed of dam (table 9). Steers from Angus dams produced smaller carcasses ($P<.001$) and had less carcass weight per day of age ($P<.06$) than those from Brown Swiss dams. Steers from Angus dams also had a smaller average ribeye area ($P<.04$) and lower maturity score ($P<.02$). Steers from the F_1 Angus x Brown Swiss crossbred dams were intermediate to and significantly different from those from the two parent breeds for the traits listed above, except that they did not differ significantly from those produced by Brown Swiss dams for carcass maturity. Breed of dam had a greater effect on carcass weight per day of age than did breed of sire (table

9). Brown Swiss cows weaned the heaviest calves, followed by the F_1 Angus x Brown Swiss crossbreds and the Angus (Olson et al., 1985). Since preweaning gain contributes to carcass weight per day of age, part of the breed of dam effect on carcass weight per day of age was undoubtedly due to different preweaning daily gains resulting from different levels of milk production by the three breed groups of dam.

Breed of Sire by Breed of Dam Interactions

Breed of sire by breed of dam interactions significantly affected marbling score and tenderness (table 11). The F_1 steers nursing Brown Swiss dams had the highest marbling score of all groups, while the F_1 steers nursing the Angus dams produced carcasses with nearly one degree less marbling. Similarly, when steers of like breed composition but nursing different breeds of dam were compared, the more tender steaks were from those that nursed cows with a higher percentage of Brown Swiss breeding. Since the Brown Swiss cows produced more milk (Euclides et al., 1983), these data may suggest a preweaning nutritional effect on marbling and meat tenderness.

TABLE 11. LEAST SQUARES ESTIMATES ± SE FOR MARBLING SCORE AND WARNER-BRATZLER SHEAR FORCE VALUE BY BREED OF SIRE AND BREED OF DAM

	Breed of sire		
Breed of dam	Angus (A)	Brown Swiss (BS)	F_1 (AxBS)[a]
	Marbling[b]		
Angus	4.21 ± .23	4.06 ± .25	3.88 ± .20
Brown Swiss	5.04 ± .26	3.43 ± .25	3.53 ± .21
F_1 (AxBS)[a]	3.62 ± .20	3.80 ± .20	4.01 ± .18
	Warner-Bratzler shear force (kg)		
Angus	4.3 ± .4	5.2 ± .4	4.4 ± .3
Brown Swiss	4.5 ± .4	5.5 ± .4	4.0 ± .3
F_1 (AxBS)[a]	4.1 ± .3	4.7 ± .3	4.9 ± .3

[a]Reciprocal crosses combined.
[b]3=slight, 4=small

SUMMARY

One hundred and thirty-two steers, born in 1979 and 1980, from Angus (A), Brown Swiss (BS), and A x BS reciprocal crossbred cows (F_1) bred to A, BS, or F_1 bulls were full-fed by breed groups from weaning until they reached the slaughter endpoint of about 1 cm outside fat. Steers were slaughtered at the University Meats Laboratory, carcass quality and yield grade data were collected, and Warner-Bratzler shear force values obtained on loin steaks. The mathematical model used to determine main and interaction effects included breed of sire, breed of dam, year, all two-way interactions, plus initial age and fat over the ribeye as covariates. Maternal and individual components of heterosis and additive breed effects were estimated, based on the assumption that individual and maternal components combine additively, and that heterosis is linear with respect to the percentage of loci where alleles originate from different breeds. Additive effects for the Angus breed were expressed as deviations from the Brown Swiss.

The maternal additive effects of the Angus breed were significant only for traits related to weight, and were negative for initial feedlot weight, final feedlot weight, weight per day of age, carcass weight, and carcass weight per day of age. The individual additive effects of the Angus were significant and negative for all feedlot traits except average daily gain. The individual additive effects

of the Angus significantly decreased weight-related traits, but improved marbling and tenderness. Maternal heterosis was of significant magnitude only for initial feedlot weight, slaughter age, and days on feed, all of which were in the desirable direction. Individual heterosis was significant only for carcass maturity and marbling.

Breed of sire significantly affected all growth parameters of postweaning performance, days on feed, and slaughter age. Likewise, breed of sire affected all carcass characteristics except ribeye area per 100 kg of carcass and percentage of kidney, pelvic and heart fat. When compared to Brown Swiss, Angus bulls caused a decrease in initial feedlot weight, final feedlot weight, weight per day of age, days on feed, dry matter intake, carcass weight, carcass weight per day of age, cutability, ribeye area and maturity, and an increase in marbling and tenderness. The F_1 Angus x Brown Swiss-sired steers were intermediate to the steers from Angus and Brown Swiss sires for all of these traits. However, they did not differ significantly from the Angus-sired steers for initial feedlot weight, live and carcass weight per day of age, and tenderness, or from Brown Swiss-sired steers for yield grade and marbling.

Breed of dam significantly affected all postweaning performance traits except average daily gain, and also affected carcass weight, carcass weight per day of age, carcass maturity and ribeye area. Steers from Angus dams, when compared with those from Brown Swiss dams, had a decrease in initial feedlot weight, final feedlot weight and slaughter age, live and carcass weight per day of age, days on feed, total and daily dry matter intake, feed to gain ratio, carcass weight, ribeye area, and carcass maturity. Steers from F_1 Angus x Brown Swiss dams were intermediate to those from Angus and Brown Swiss dams for all of the above traits, and were significantly different than both for all traits except daily dry matter intake, feed to gain ratio, and carcass maturity, where they differed only from the steers from Angus dams.

Breed of sire by breed of dam interactions were significant for days on feed, slaughter age, average daily gain, marbling, and tenderness. The fastest gaining breed type was the three-fourths Angus steers. Breed of sire by breed of dam interactions for tenderness were due to the fact that, within breed of sire, increases in Brown Swiss breeding in the dam caused an increase in meat tenderness, suggesting a preweaning nutritional effect on tenderness.

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BIOGRAPHICAL SKETCH

Timothy Thad Marshall was born November 8, 1957, in Bangor, Maine. He graduated from the public school system of Cook County, Georgia, in June, 1975. During his high school years, he was active in 4-H and FFA clubs, and was elected local president of both organizations. He entered Abraham Baldwin Agricultural College in September, 1975, and was awarded the Associate of Science degree in agriculture in June, 1977. In September, 1977, he entered the University of Georgia and was awarded the degree of Bachelor of Science in agriculture in June, 1979, with a major in animal science. At the University of Georgia, the author was president of the Block and Bridle Club and received the Outstanding Senior in Animal Science Award from the faculty. He was a member of the 1978 University of Georgia Livestock Judging Team.

In September, 1979, the author was granted a graduate assistantship at the University of Florida and received a Master of Science degree in August, 1981. He pursued a degree of Doctor of Philosophy in animal science until March, 1982 when he accepted the position of Livestock Extension Agent for Alachua County, Florida. He re-entered his graduate program during May, 1985 and has pursued the degree of Doctor of Philosophy since then.

He is married to the former Robin René Marks and is the father of two children, René and Glen.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Don D. Hargrove

Don D. Hargrove, Chairman
Associate Professor of Animal Science

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

D. L. Wakeman

D. L. Wakeman
Professor of Animal Science

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William E. Kunkle

W. E. Kunkle
Associate Professor of Animal Science

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Jimmy G. Cheek

J. G. Cheek
Professor of Agricultural & Extension Education

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Dwain Johnson

D. D. Johnson
Assistant Professor of Animal Science

This dissertation was submitted to the Graduate Faculty of the College of Agriculture and to the Graduate School, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

May 1986

Jack L. Fry

Dean, College of Agriculture

Dean, Graduate School