PRODUCTIVITY AND ECONOMIC COMPARISONS AMONG TWO-BREED CROSS COW GROUPS PRODUCING THREE-BREED CROSS CALVES

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NOMENCLATURE

avg	average
cm	centimeters
d	days
df	degrees of freedom
g	grams
h	hours
kg	kilograms
se	standard error
tdn	total digestible nutrients
wt	weight
yr	years

CHAPTER I

INTRODUCTION

The use of crossbreeding has been increasingly accepted in commercial beef enterprises as producers attempt to increase production through utilization of heterosis and/or breed complementarity. Research involving British beef breeds has indicated that planned crossbreeding systems can increase productivity per cow exposed to breeding by 20 % or more (Cundiff, 1970). Since heterosis is maximized as genetic divergence between breed types increases, even greater increases in productivity may result when British breeds are crossed with some of the exotic continental European breeds. It is important to evaluate existing germ plasm resources for potential use in systematic crossbreeding.

Production output traits that are relatively easy to measure, such as growth rate, have often been used as primary selection criteria, both when evaluating animals on a within-herd basis and when evaluating breed types in research studies. The benefits of increased growth rate from producing given quantities of beef in less time are well recognized, but the efficiency of production must be considered as well. Reproduction, feed conversion, carcass composition and marketing systems also influence economic efficiency. Hence, various traits need to be evaluated simultaneously in order to account for all factors influencing net profits. To determine the potential worth of breed types to the industry, all segments of production must be evaluated, i.e., cow-calf, feedlot and carcass. Systems analyses have been utilized to investigate net economic efficiency of beef production, taking into account various production segments, as well as alternative breeding systems, management and marketing strategies.

Numerous research studies have been designed to evaluate productivity of specific breed combinations under given environmental conditions. This study is a portion of a research project currently in progress at the Oklahoma Agricultural Experiment Station designed to evaluate lifetime productivity of various types of two-breed cross cows (Hereford X Angus, Angus X Hereford, Simmental X Angus, Simmental X Hereford, Brown Swiss X Angus, Brown Swiss X Hereford, Jersey X Angus and Jersey X Hereford) when mated to bulls of a third breed. Individual feed consumption and efficiency to weaning, expressed as kg annual cow-calf TDN per kg 205-d calf weight, was reported for smaller samples of these crossbred cow groups by Marshall et al. (1984). Objectives of this study were to evaluate (1) cow productivity and calf performance from birth to weaning, (2) postweaning feedlot performance of calves and (3) carcass traits of slaughter calves of specific two-breed cross cow groups in a terminal crossbreeding system. An additional objective was to evaluate economic efficiency of these crossbred cow groups under alternative marketing and management strategies, utilizing a bioeconomic model based on actual research data and a simulated production system.

CHAPTER II

REVIEW OF LITERATURE

Characterization of Two-Breed Cross Cows

Results from beef cattle crossbreeding research have been summarized by Cundiff (1970), Franke (1980) and Long (1980). Results indicate that over half the increased productivity from crossbreeding is due to maternal heterosis, exhibited by the crossbred cow, for reproduction and maternal traits important for early calf growth and survival. Hence, it is important to identify specific crossbred cow types which perform well in given mating systems and under particular environmental conditions. Gregory (1982) estimated that half of the increased output in weaned calf production resulting from heterosis and complementarity from crossbreeding could be obtained with no additional feed resources and with a small decrease in number of breeding herd females.

Two-breed cross cow groups represented in the present study are Hereford X Angus, Angus X Hereford, Simmental X Angus, Simmental X Hereford, Brown Swiss X Angus, Brown Swiss X Hereford, Jersey X Angus and Jersey X Hereford. Studies involving these crossbred cow groups are summarized in Tables I through V. Breed types not used in the present study are occasionally referred to for comparison purposes.

Table I summarizes cow reproductive performance, including gestation length, calving rate and weaning rate. Small differences were reported in gestation length among Hereford X Angus reciprocal crosses, Simmental crosses and Jersey crosses by Notter et al. (1978a) and Bowden (1977). Bowden (1980) reported a higher weaning rate for Simmental X Angus cows (90.3 %) than for Hereford X Angus or Jersey X Angus cows (averaged 70 %). Laster et al. (1976) reported a higher calving rate for Hereford and Angus reciprocal cross cows (93.0 %) than for Simmental or Jersey crosses (averaged 86.3 %). Belcher and Frahm (1979) reported a wide range in percent weaned for 2-year-old cows, varying from 89.8 % for Jersey cross cows to 53.3 % for Simmental X Angus cows. Nelson et al. (1982) reported weaning rates of 76.8 and 83.4 % for Angus X Hereford and Brown Swiss X Hereford cows, respectively. Small differences in percent weaned were reported by Jenkins and Ferrell (1983) among reciprocal Hereford and Angus crosses, Simmental crosses and Jersey crosses, and by Steffan et al. (1983) among Angus X Hereford and Simmental X Hereford cows.

Calf birth weights, weaning weights and calving difficulty are presented in Table II. In studies including Hereford X Angus and/or Angus X Hereford cows as a reference, birth weights of calves from Simmental cross and Brown Swiss cross cows averaged 2.5 and 3.7 kg heavier and calves from Jersey cross cows averaged 2.5 kg lighter than calves from Hereford X Angus and reciprocal cross cows. Based on deviations calculated from 6 studies, Simmental cross calves had an average of 20 kg heavier weaning weights than calves from Hereford X Angus and/or reciprocal cross cows. Belcher and Frahm (1979) reported 29.5 kg heavier weaning weights for Brown Swiss cross calves than for calves from Hereford X Angus and reciprocal cross cows, and Nelson et al. (1982) reported 30 kg heavier weaning weights for calves from Brown Swiss X Hereford cows than calves from Angus X Hereford cows. Jersey cross calves averaged 15 kg heavier in studies reported by Notter et al. (1978b) and Belcher and Frahm (1979), but only 2 kg heavier in studies reported by Bowden (1980) and Long (1981), than calves from Hereford X Angus and/or reciprocal cross cows. Calving difficulty averaged 34.1, 38.6 and 18.1 % for Hereford and Angus reciprocal crosses, Simmental crosses and Jersey crosses, respectively, in studies reported by Notter et al. (1978a) and Belcher and Frahm (1979). Nelson and Beavers (1982) reported calving difficulty for Angus X Hereford and Brown Swiss X Hereford cows, respectively, of 15.9 and 12.1 % when mated to Angus bulls, and 30.4 and 25.7 % when mated to Charolais bulls.

Cow weights and milk yield estimates are presented in Table III. Although weights of mature cows of these crosses were generally not available, some general characterizations can be made. Relative to Hereford X Angus and Angus X Hereford cows, Simmental and Brown Swiss cross cows are characterized as heavier in weight and heavier milking, while Jersey crosses are smaller in size, but heavier milking. Milk production of Jersey crosses was equal to or greater than that of Simmental crosses, based on data from 5 studies. Brown Swiss and Jersey cross cows produced similar quantities of milk in studies reported by Belcher and Frahm (1979) and Chenette and Frahm (1981).

Feedlot data for calves from these crossbred cow groups are limited (Table IV). Young et al. (1978) reported faster feedlot gains for calves from Hereford and Angus reciprocal cross and Simmental cross cows (average 1.07 kg/day) than for Jersey cross calves (.98 kg/day). Jersey cross calves were 14 kg heavier at 200 d of age, but 7 kg lighter at 452 d than calves from Hereford and Angus reciprocal cross cows. Restle et al. (1983) reported that calves from Brown Swiss X Angus reciprocal cross cows required .44 kg less dry matter intake per kg of live weight gain than calves from straightbred Brown Swiss cows, but .66 kg/kg more than calves from straightbred Angus cows.

Young et al. (1978) reported carcass data of steer calves from 2-year-old Hereford X Angus and reciprocal cross, Simmental X Angus, Simmental X Hereford, Jersey X Angus and Jersey X Hereford cows (Table V). Means were adjusted to a common slaughter age of 468 days. Carcasses from Simmental cross calves had less external and internal fat, larger _longissimus_ areas, lower yield grades and higher estimated retail product than carcasses from Hereford and Angus reciprocal cross and Jersey cross calves. Differences in carcass weight, marbling score and quality score were not significant. No differences between Hereford X Angus and reciprocal cross versus Jersey cross calves were significant.

Biological Efficiency of Beef Production With Reference to Breed Type and Mature Size

Weaned Calf Production. Because of high maintenance overhead for the breeding herd, feed costs represent a major portion of expenses in a beef cow-calf enterprise. Likewise, the feed energy requirements for the cow-calf segment of the beef industry comprises a major portion of the total feed energy required to produce edible beef. Cartwright (1970) emphasized the importance of the efficiency of the breeding herd, noting that approximately two cattle must be maintained for each sale calf produced. Gregory (1972) estimated that approximately 65 percent of the total feed nutrients used for producing beef are required for weaned calf production. Ritchie (1983) estimated that 55 percent of the entire total digestible nutrients (TDN) utilized for beef production is required to maintain the breeding herd. Of course, there is some retail output from the breeding herd from cull cows and bulls, but there is also a maintenance requirement for the postweaning segment of beef production. Based on a summary of four studies, Ritchie (1983) indicated that of the total feed energy used in beef production, the proportion utilized for maintenance was approximately 75 to 80 %, which leaves 20 to 25 % for production.

Several research studies have shown positive relationships between cow weight and calf growth rate (Brinks et al., 1962; Voccaro and Dillard, 1966; Jeffery et al., 1971; Urick et al., 1971; Jeffery and Berg, 1972; Miguel et al., 1972; Benyshek and Marlowe, 1973; Klosterman et al., 1974) and between milk production and calf growth (Knapp and Black, 1941; Neville, 1962; Velasco, 1962; Totusek et al., 1973; Franke et al., 1975; Belcher and Frahm, 1979; Chenette and Frahm, 1981). Because of these relationships, continuing interest has been shown in the use of larger continental European breeds and in the use of dairy breeding in beef herds. To be economically justified in their use, breed types of larger size and/or greater milk production must wean calves of sufficiently greater weight to offset increased feed costs.

The relationship of efficiency of calf production with cow size and condition was studied by Kress et al. (1969) who analyzed individual feed consumption data from 56 fraternal and identical twin Hereford cows producing 135 lactation records. Efficiency estimates were unfavorably related to cow weight at calving and to the ratio of weight to height at the withers. The relationship between efficiency and cow height at the withers was generally positive, but seldom significant. Thus, they hypothesized that cows of varying skeletal size differ little in efficiency of weaned calf production, but that fatter cows may be less efficient.

Carpenter et al. (1972) reported data from 30 Hereford and 15 Charolais cows fed individually in a drylot to maintain similar fatness in all cows. Charolais cows were more efficient than Herefords based on the ratio of calf weaning weight to cow-calf feed consumption during lactation. Although efficiency was not significantly affected by mature cow size, it was favorably associated with milk yield and calf growth.

Onks et al. (1975) reported a study with individually fed Angus cows and calves, including 118 cow-years over a five year period. Cow weight significantly affected annual intake of TDN of cow and calf, but not the ratio of cow-calf TDN intake per unit of calf weaning weight.

Marshall et al. (1976) reported data from individually fed Angus, Charolais and reciprocal cross cows and their Polled Hereford sired calves. The data set included 73 cows and 122 weaning records. Breed of dam was a significant source of variation for cow weight and cow-calf intake of TDN, but not for calf weaning weight or efficiency (kg cow-calf TDN per kg weaning weight). Weaning efficiency was favorably associated with weaning weight (correlation, r=-.87) and milk production (r=-.52), but not significantly associated with cow weight (r=-.04).

Bowden (1980) evaluated weaning efficiency of two-year-old crossbred cows of varying potential mature size and milk production. Records of 28 Simmental X Angus, 27 Charolais X Angus, 23 Hereford X Angus and 21 Jersey X Angus cows individually fed one of two levels of energy intake ("normal" and "normal" + 10 percent) were included. Jersey X Angus dams weaned a greater percentage of dam weight postcalving than Charolais X Angus dams (61.6 vs 55.0 percent) and a greater percentage of dam weight taken at weaning than all the other breed types (59.7 vs an average of 52.4 percent). However, breed types did not vary significantly in Mcal cow-calf DE intake per kg calf weaning weight. These results support the conclusion of Dinkel and Brown (1978) and Gregory (1982) that efficiency estimates based on the ratio of calf weaning weight to cow weight are generally biased in favor of smaller breed types.

Filho et al. (1983) reported weaning efficiency data from group fed cows producing a total of 108 calves. Cow breed types included Angus, Brown Swiss, and reciprocal crosses which were mated to bulls of the same breed types in a diallel scheme. Calf weaning weight and estimated milk yield were greatest for Brown Swiss dams (250 and 16.6 kg), intermediate for reciprocal cross dams (222 and 13.6 kg) and lowest for Angus dams (187 and 10.6 kg). Cow-calf group TDN per unit of calf weaning weight significantly favored Angus dams (7.35 kg/kg) over Brown Swiss and reciprocal cross dams (averaged 8.6 kg/kg).

Marshall et al. (1984) evaluated feed efficiency to weaning of 105 individually fed two-breed cross cows (Hereford X Angus reciprocal crosses, Simmental X Angus, Simmental X Hereford, Brown Swiss X Angus, Brown Swiss X Hereford, Jersey X Angus and Jersey X Hereford) mated to Charolais or Limousin bulls. Brown Swiss X Hereford and Jersey X Hereford groups consumed less TDN per unit 205-d calf weight than the Simmental X Angus group (10.0 and 9.9 vs 11.0 kg/kg), while differences evaluated by other two-way comparisons were not significant. In a separate analysis in which differences in cow weight change were taken into account, crossbred cow group was not a significant source of variation for this estimate of efficiency.

Efficiency to Slaughter. To compare the net value of various beef cattle breed types, their contributions to all phases of the industry must be considered. Because of the high costs of individual feeding, relatively few studies have evaluted cow-calf efficiency of weaned calf production. The subsequent efficiency of calves after weaning is also an important component of efficiency of the total system, and numerous research studies have evaluated feedlot performance of calves. However, few studies have been designed to look at the feed efficiency of the cow-calf unit through slaughter.

Melton et al. (1967) reported weaning efficiency of 30 Hereford and 15 Charolais individually fed cows and their progeny. Although Charolais cows were heavier, produced heavier calves, consumed more TDN and produced more milk than Hereford cows, there was little difference between breeds in amount of cow-calf TDN per unit calf weight produced at weaning (8.4 and 8.7 for Charolais and Hereford, respectively) or at slaughter (7.2 and 7.3 for Charolais and Hereford, respectively).

Klosterman et at. (1974) evaluated total feed efficiency through calf slaughter of 133 individually fed Hereford, Hereford X Angus, Hereford X Charolais and Charolais cows and their calves (sired by Hereford or Charolais bulls). Cows were also grouped into three weight classes to evaluate the effects of cow size on efficiency. Cow breed type effects were significant for weaning efficiency (annual cow TDN plus calf creep TDN divided by calf weaning weight), but cow weight group effects were not significant. Hereford X Angus cows were most efficient through weaning (8.6 kg/kg), followed by Charolais (9.2 kg/kg) and Hereford X Charolais and Hereford (averaged 10.05 kg/kg). Calves of the heaviest milking cow group (Hereford X Angus) were least efficient in the postweaning feedlot phase. Efficiency to slaughter, calculated as the ratio of annual cow TDN plus calf TDN through slaughter to kg edible portion produced, did not differ significantly among cow breed or size groups.

Oklahoma researchers studied performance of Hereford, Hereford X Holstein and Holstein cows receiving varying levels of supplementation and mated to Angus and Charolais bulls (Kropp et al., 1973; Holloway et al., 1975a; Wyatt et al., 1977). Feed intake, milk yield and calf weaning weight were highest for Holsteins, intermediate for Crossbreds and lowest for Herefords. Efficiency to four end points (milk, weaned calf, carcass energy and retail cuts) was reported for the two- and three-year-old cows by Holloway et al. (1975b). Holsteins were most efficient in conversion of digestible energy (DE) consumed by cow to milk energy, whereas Herefords were most efficient in conversion of milk and calf creep feed DE to calf weaning weight. Differences in conversion of cow and calf intake to calf weaning weight were generally nonsignificant (P>.05). Cow and calf DE intake was converted to carcass gross energy of calves most efficiently by the Hereford dam group, followed by Crossbreds and Holsteins. The Hereford and Crossbred groups were similar in conversion of cow-calf DE intake to trimmed retail weight and somewhat superior (P<.10) to Holsteins.

Martin and McReynolds (1979) evaluated feed efficiency through calf slaughter of individually fed cows weaning 57 calves over a three year period. First year calves were sired by a Shorthorn bull and second year calves were sired by a Charolais bull. Annual kg TDN per kg calf weaning weight averaged 9.8, 8.8 and 8.3 for Angus X Hereford, Simmental X Angus and Jersey X Angus crossbred cow groups, respectively. Feedlot and carcass data were available on the individually fed calves for the first two years of the study. Although least efficient to weaning, the Angus X Hereford group was most efficient in feedlot. Kilograms TDN per kg gain in the feedlot averaged 5.1, 5.6 and 5.5 the first year and 4.8, 5.1 and 4.8 the second year for Angus X Hereford, Simmental X Angus and Jersey X Angus groups, respectively. Combining cow herd and feedlot data for the first two years of the study, kg cow-calf TDN per kg calf slaughter weight averaged 7.4, 7.4 and 6.8 and kg cow-calf TDN per kg hot carcass weight averaged 11.9, 11.7 and 11.1 for Angus X Hereford, Simmental X Angus and Jersey X Angus groups, respectively.

Brown and Dinkel (1982) reported efficiency through slaughter of 62 Angus, Charolais and reciprocal cross cows producing 227 calves over five years. Calves were out of Polled Hereford, Salers and Limousin bulls. Crossbred cow groups did not vary significantly in conversion of cow TDN plus calf preweaning TDN to calf weaning weight or in conversion of cow TDN plus calf TDN through slaughter to calf retail cuts. However, Angus cow-calf pairs were more efficient than other breed types in conversion of cow TDN plus calf TDN through slaughter to calf slaughter weight (8.3 vs average of 8.5 kg/kg).

Davis et al. (1983 a,b) evaluated life cycle weaning efficiency of 160 beef, dairy and beef X dairy cross cows and their progeny. Individual feed consumption of dams was measured from 240 days of age until three calves were weaned or until dams were five years of age. Intakes of dams prior to 240 days of age were estimated. Efficiency was estimated by the ratio of outputs (calf weaning weights and cull cow salvage weights) to inputs (cow lifetime feed intake and progeny creep feed intake). In one approach, outputs and inputs were weighted by their respective probabilities of occurrence, based on the age distribution and percentage calf crop of a theoretical herd consisting of 100 cows and 20 replacement yearlings. In a second approach, actual lifetime efficiency was estimated on cows which weaned three calves by weighting components equally. Under both approaches, efficiency ratios were calculated with and without cow salvage weight. In one data set, Hereford X beef dams were most efficient, followed by Hereford, Hereford X dairy and Holstein dams for all four lifetime weaning efficiency ratios. Holstein dams were least efficient even though they weaned the heaviest calves and produced the heaviest salvage weights. The authors reasoned that Holstein dams consumed excess feed to produce greater than optimum levels of milk since

Holstein dams were mated to a relatively small sire breed (Hereford). In a separate analysis, Hereford cows mated to Holstein sires were significantly more efficient in production of weaned calves than Holstein cows mated to Hereford sires. In a second data set in which cows were mated to Jersey bulls for their first calf and to Charolais bulls for their second and third calves, dam breed type was not a significant source of variation for weaning efficiency among Hereford X Holstein, Angus X Holstein, Simmental X Holstein and Chianina X Holstein cows. Davis et al. (1983a) concluded that cows should be "challenged" by mating them to bulls as large as can be used without excessive calving difficulty.

Davis et al. (1983b) indicated that selection of dams at an early age for lifetime efficiency of weaned calf production based on weight, height and weight:height ratio at 240 days of age would not be effective, since these traits were not significantly correlated with subsequent weaning efficiency. However, weights of dam at calving and at weaning of her progeny were negatively correlated with efficiency ratios (r ranged from -.24 to -.59), indicating an advantage for smaller cows. Correlations of cow height with efficiency were negative and generally significant (r ranged from -.15 to -.37). Cow weight:height ratio was negatively correlated with efficiency ratios (r ranged from -.18 to -.58), indicating a tendency for fatter cows to be less efficient. Correlations of efficiency with milk production were unfavorable when relatively small sires (Jersey) were used (r ranged from -.11 to -.29), but near zero when larger Charolais sires were used. Hence, the authors concluded that choice of sire should complement size and milk yield potential of dams.

Postweaning performance and lifetime efficiency of slaughter calf production of these cattle were reported by Davis et al. (1984a,b). In the first data set, dam breed group was not a significant source of variation for postweaning feed efficiency. Ratios evaluating lifetime efficicency of slaughter calf production (outputs included slaughter weights, carcass weights or trimmed wholesale cuts; inputs included progeny and dam feed intakes) favored Hereford X beef or Hereford dam breed groups, followed in order by Holstein X dairy and Hereford groups. In the evaluation of reciprocal effects of Holstein dams mated to Hereford sires vs Hereford dams mated to Holstein sires, postweaning efficiencies of dam breeds were similar; however, the advantage for Hereford dams through weaning resulted in Hereford dams being more efficient in lifetime slaughter calf production than Holstein dams. In the second data set, second and third parity progeny from Simmental X Holstein and Chianina X Holstein dams tended to be more efficient after weaning than progeny from Hereford X Holstein and Angus X Holstein dams. However, differences among dam breed groups in data set two were not significant for efficiency of slaughter calf production. The importance of reproductive performance and calf liveability to net lifetime efficiency of beef production were noted.

Jenkins and Ferrell (1983) estimated metabolizeable energy requirements for Hereford X Angus reciprocal cross, Simmental X Angus, Simmental X Hereford, Jersey X Angus and Jersey X Hereford cows and for their progeny sired by Brown Swiss bulls. Calves were fed to an age constant postweaning end point. Kilograms calf weaning weight per cow exposed to breeding, commonly used as an estimate of efficiency to weaning, averaged 221, 203 and 203 for Simmental, Hereford X Angus reciprocal and Jersey crosses, respectively. However, energetic efficiency to slaughter estimated as progeny retail product yield per cow divided by estimated cow-calf metabolizeable energy intake, favored Hereford X Angus reciprocal crosses (16.4 g/Mcal) over Jersey crosses (15.2 g/Mcal) and Simmental crosses (15.1 g/Mcal).

Wagner et al. (1984) evaluated biological efficiency of 140 individually fed Angus, Hereford, Charolais and reciprocal cross cows and their calves. Cows were fed an average of 315 days. Breed of dam effects were not significant for the weaning feed efficiency ratio of 180-day calf weight to cow-calf TDN intake (although breed of calf effects were significant). Weaning efficiency was not closely associated with hip height of the dam (r=-.02). Although correlations of weaning efficiency with cow weight at calving (r=-.24) and at weaning (r=-.30) were unfavorable, the authors note these results may have been caused by heavier cows being fatter. Breed of dam effects on conversion of cow-calf TDN to final weight or to lean carcass weight were not evaluated. However, breed of calf effects were significant, with the most efficient calf type being out of Angus X Hereford dams mated to Charolais bulls. Wagner et al. (1984) noted the apparent complementarity of this smaller F_1 dam breed type mated a to larger type sire for feed total feed efficiency to slaughter. Urick et al. (1984) analyzed this same data set to evaluate the effects of crossbreeding on feed efficiency of the cow-calf unit. Heterosis for cow-calf feed efficiency for weaning, slaughter and carcass weight production, respectively, averaged 2.0, 1.8 and 2.1 %

for two-breed cross cows producing backcross calves, and 1.6, -.8 and .6 % for two-breed cross cows producing three-breed cross calves.

Economic Efficiency of Beef Production Including Systems Analysis Applications

In a review of uses of quantitative genetic engineering in improving the efficiency of animal production, Dickerson and Willham (1983) recognize the need for taking into account all production segments, including the marketing system, when evaluating the efficiency of alternative genetic types and management systems. Dickerson (1978) referred to the limited usefullness of biological efficiency, noting that a unit of feed energy may vary in monetary cost according to stage of growth and/or production, and that monetary returns per unit of product output may vary according to classification of product. For example, costs per kg TDN may differ for breeding cows vs feedlot calves, and values of various classes of sale calves and culled breeding animals must be weighted by their relative economic values. In addition, the importance of non-feed costs which are generally greatly influenced by biological performance variables also need to be considered (Dickerson, 1978). However, Cartwright (1979) notes that efficiency ratios such as sale live weight output per unit of TDN input are closely related to economic efficiency, but are less variable over short time spans.

The use of systems analysis and computer simulation techniques lend themselves well to economic evaluations of various aspects of beef production. Alternative price structures, alternative management schemes, maximizing income, minimizing expenses, range and sensitivity of so-called "optimal" solutions are examples of types of analyses in which calculations are greatly expedited by use of computer simulation technology. The systems analysis approach is useful in tying together various segments of beef production, taking into account biological and economic relationships of variables within and between these segments. Alternative management systems, price structures, genetic potential and possible interactions among these can be evaluated in simulated production systems. Such work in swine systems has been reported recently by Tess et al. (1983a,b,c) and by Bennett et al. (1983a,b). A beef simulation model developed by researchers at Texas A&M University has been used in a number of applications (Sanders and Cartwright, 1979a,b). Several studies evaluating economic efficiecy of varying genetic types of cattle are discussed in the following section of this manuscript.

Long et al. (1975) used linear programming techniques in a systems analysis approach to evaluate the effects of cow size on efficiency of beef production. Three genetic types grouped according to mature size (small, medium and large) were compared under two management regimes (pasture and drylot). Linear programming allows the user to determine which set of alternative production activities results in optimizing an objective function under a set of constraints. The objective function defined by Long et al. (1975) was maximization of net income. The primary constraint was a maximum expenditure for total feed nutrients of $100,000. Thus, more cows of a smaller genetic mature size could be maintained than cows of a larger size. Since prices for drylot feedstuffs were set higher than for pasture nutrients, more cows could be maintained under the pasture regime. Growth parameters assumed in the simulation were based on research data from cattle of varying mature size. Nutrient requirements were estimated. Relative price coefficients were assumed to be realistic at the time of the study. If prices changed in parallel, then results would be applicable at other times as well. The model was deterministic in that solutions were the direct result of the assumed input data (an assumption of linear programming is that coefficients are known exactly). An integrated production system, including both cow-calf and feedlot phases, was simulated. The results of the study indicated an interaction between mature size and management regime. Systems with small cows produced more live weight and gross income, but expenses were greater also. Net income and return on investment were highest for large cows under the drylot regime where feed costs were relatively high. Under the pasture regime, small cows had the highest net income but a slightly lower return on investment than large cows. Medium size cows were intermediate for net income under both systems and for return on investment for the drylot regime, but were comparable to large cows for return on investment for the pasture regime. Sensitivity analyses indicated that varying cattle prices and ratios of cull cow to slaughter calf prices had little effect on profit rankings.

The results of Long et al. (1975) were based on a straight breeding system. The model was also used to investigate the effects of heterosis and genetic complementarity (Fitzhugh et al., 1975) and the effects of mating systems (Cartwright et al., 1975) on economic efficiency of an integrated beef production sytem. Results indicated that within a given cow size genotype, it was more profitable to produce larger calves, taking advantage of a large terminal sire. Heterosis for growth and calf survival was economically advantageous. Mating large sires to F_1 cows was comparable to mating large sires to cows produced in a two-breed rotation. Both these systems producing three-breed cross calves were economically superior to crosses involving two breeds.

Morris and Wilton (1976, 1977) also used linear programming to evaluate the effects of cow size and mating system on efficiency of production. The terminal cross system resulted in larger farm gross margins than straightbreeding or rotational crossing when calves were sired by larger bulls mated to smaller F_1 cows. However, potential reductions in reproductive efficiency because of calving difficulty resulting from the use of large sires was not considered in the model.

Smith (1976) evaluated sire breed effects on economic efficiency in a 2-breed terminal cross system. Results were based on research data from a specific experiment (including calving difficulty, growth, calf survival, feedlot performance, carcass composition and carcass grade), estimated cow feed costs, and additional estimated production costs and intuitive assumptions. Calves were produced by Hereford and Angus dams mated to Hereford, Angus, Jersey, South Devon, Simmental, Charolais and Limousin bulls. Despite higher levels of calving difficulty with their use, economic rankings generally favored calves sired by the larger Limousin, Charolais and Simmental breeds. Systems producing South Devon sired calves and reciprocal Hereford X Angus cross calves were intermediate in economic efficiency, followed by straightbred Hereford and Angus calves. Crossbred calves sired by the smaller Jersey bulls ranked low in all comparisons.

Notter (1979a,b,c) simulated an integrated cow-calf-feedlot system, evaluating effects of milk production, mature body size and crossbreeding systems on biological and economic efficiency. Animal performance was predicted using a modified version of the Texas A&M Cattle Production Systems Model (Sanders and Cartwright, 1979a,b). Results indicated that when increasing milk yield was associated with increasing weaning rate by improving calf survival, economic efficiency was generally improved. When increasing milk yield resulted in decreased pregnancy rates, economic efficiency was diminished. If cattle of different size classes were fed to a similar degree of maturity, then mature size had no apparent effect on the amount of TDN input per unit of beef output (i.e., biological efficiency). Since many non-feed costs are independent of size and are on a "per cow" basis, costs per unit of output were generally less for cattle of larger mature size. However, this result depended on the relative price of cow herd to feedlot TDN. Assuming calves are weaned at a constant age, then the proportion of a calf's growth occurring postweaning increases as mature size increases. Thus, at relatively high feedlot to cow herd TDN price ratios, economic efficiency favored small cows. Systems using both maternal and individual heterosis were more efficient than systems using only individual heterosis.

Summary

Rising production costs and continuing competition from alternative food sources have increasingly created demand for methods of improving efficiency of beef production. Favorable relationships of cow size and milk yield with calf preweaning growth rate have helped create interest in introducing larger "exotic" and dairy breeds into commercial beef herds. Several studies are currently in progress with the purpose of evaluating level of performance of a wide array of breeds and crosses under commercial production conditions.

Crossbreeding has been increasingly accepted as a method of improving efficiency in commercial beef enterprises. Maternal heterosis especially benefits reproduction,as well as calf survival and growth to weaning, traits of considerable economic importance. "Specialized" breed types that emphasize either maternal or paternal performance (Smith, 1964; Cartwright, 1970; Smith, 1979) and exploit size divergence between sire and dam lines, make use of breed complementarity. Use of such terminal sire crossbreeding systems would likely be greatly enhanced by technology allowing sex manipulation (Gregory and Cundiff, 1980).

Studies pertaining to the influence of mature size and/or biological type on efficiency of production have not been conclusive. The concept of optimal size of beef cows has been often discussed. Cartwright (1979) suggested that some potential probably exists for increasing efficiency by matching cow type to a particular set of environmental conditions and management constraints. Wyatt et al. (1977) concluded that "optimal level of milk production and consequently calf weaning weight in the beef cow herd is a moving target dependent on many factors". Results from several studies suggest that cows of higher milk yield potential should be mated to a larger breed of sire to efficiently utilize increased energy requirements associated with increased milk levels. The existence of genotype x environment interactions, as well as changing market conditions and consumer preferences, dictate the likelihood that genetic variation between and within breeds has been and will continue to be desirable. Additional research designed to identify breed types which peform well under given conditions, particularly studies which evaluate efficiency in integrated production systems, seems warranted.

TABLE I

CHARACTERIZATION OF TWO-BREED CROSS COWS: COW REPRODUCTIVE PERFORMANCE

Source	Cow Breed Type^a	Cow Age at Calving, Years	Calf Sire Breed	No. Cows Exposed	Gestation Length, Days	Calving Or Pregnancy Rate, %^{b}	Weaning Rate, %^{b}
Patterson et al. (1974)	HH	3-6	Hereford	67		88.1	80.6
	BH			72		90.3	88.9
Bowden (1977, 1980)	HA	2	Red Poll	33	283	75.8	69.7
	SA			31	282	93.5	90.3
	JA			30	282	83.3	70.0
Laster et al. (1976), Notter et al. (1978a)	HA, AH	2	Hereford, Angus, Brahman, Devon, Holstein	132	284	93.0	
	SA, SH			157	284	86.2	
	JA, JH			117	281	86.4	
Belcher and Frahm (1979)	HA	2	Red Poll, Shorthorn	47		85.1	68.1
	AH			58		87.9	75.9
	SA			69		81.2	72.4
	SH			45		57.8	53.3
	BA			47		93.6	85.1
	BH			50		78.0	72.0
	JA			59		89.8	88.1
	JH			59		94.9	91.5
Olson et al. (1981)	AA		Angus, Brown Swiss, Brown Swiss X Angus	Total of 731		91.0	
	BB					79.0	
	BA					95.0	

TABLE I (Continued)

Source	Cow Breed Type[a]	Cow Age at Calving, Years	Calf Sire Breed	No. Cows Exposed	Gestation Length, Days	Calving or Pregnancy Rate, %[b]	Weaning Rate, %[b]
Nelson and Beavers (1982)	AH	2	Angus, Charolais	76		93.5	
	BH			76		97.1	
Nelson et al. (1982)	AH	2-7	Angus, Charolais	76		95.7	76.8
	BH			76		97.1	83.4
Jenkins and Ferrell (1983)	HA, AH		Brown Swiss				88.2
	SA, SH						88.0
	JA, JH						86.4
Steffan et al. (1983)	AH	2		51			90.0
	SH			48			86.0

[a] A=Angus, H=Hereford, S=Simmental, B=Brown Swiss and J=Jersey.

[b] Based on number of cows exposed to breeding.

TABLE II

CHARACTERIZATION OF TWO-BREED CROSS COWS: CALF BIRTH WEIGHT, WEANING WEIGHT AND CALVING DIFFICULTY

Source	Cow Breed Type[a]	Cow Age at Calving, Years	Calf Sire Breed	No. Calves	Calf Birth Weight, Kg	Calf Weaning Weight		Calving Difficulty, %
						Calf Age Adjustment, Days	Adjusted Weight, Kg	
Patterson et al. (1974)	HH	3-6	Hereford	54	29.1	242	192	
	BH			64	30.4		229	
Notter et al. (1978a,b)	HA, AH	2	Hereford, Angus,	80	30.4	200	164	40
	SA, SH		Brahman, Devon,	116	33.0		181	46
	JA, JH		Holstein	90	28.8		181	20
	HA, AH	3	Hereford, Chianina,	77	36.1	200	188	31
	SA, SH		Maine-Anjou,	113	38.1		206	27
	JA, JH		Angus, Gelbvieh	92	33.2		196	15
Belcher and Frahm (1979)	HA	2	Red Poll, Shorthorn	33	28.6	205	168	25.0
	AH			45	27.6		168	37.3
	SA			50	31.1		192	35.7
	SH			24	30.3		187	50.0
	BA			40	30.3		203	18.2
	BH			36	30.6		192	28.2
	JA			52	26.3		189	20.7
	JH			54	27.6		189	17.9
Bowden (1980)	HA	2	Red Poll	23	34.7	200	219	
	SA			28	35.2		235	
	JA			21	31.4		222	

TABLE II (Continued)

Source	Cow Breed Type[a]	Cow Age at Calving, Years	Calf Sire Breed	No. Calves	Calf Birth Weight, Kg	Calf Weaning Weight		Calving Difficulty, %
						Calf Age Adjustment, Days	Adjusted Weight, Kg	
Olson et al. (1981)	AA		Angus	Total of 560		205	198	
	BB						251	
	BA, AB						234	
	AA		Brown Swiss				217	
	BB						267	
	BA, AB						249	
	AA		Brown Swiss X Angus, Angus X Brown Swiss				204	
	BB						242	
	BA, AB						236	
Nelson and Beavers (1982)	AH	2-7	Angus	234	31.1			15.9
			Charolais		37.1			30.4
	BH	2-7	Angus	232	36.9			12.1
			Charolais		41.4			25.7
Nelson et al. (1982)	AH	2-7	Angus	205		210	190	
			Charolais				212	
	BH	2-7	Angus	215			226	
			Charolais				236	

TABLE II (Continued)

Source	Cow Breed Type[a]	Cow Age at Calving, Years	Calf Sire Breed	No. Calves	Calf Birth Weight, Kg	Calf Weaning Weight		Calving Difficulty, %
						Calf Age Adjustment, Days	Adjusted Weight, Kg	
Long (1981)	HA, AH	First 3 Calf Crops			31.8		175	
	JA, AJ				27.7		177	
	JH, HJ				28.6		176	
Fredeen et al. (1982)	HA		Charolais, Chianina, Limousin	Total >1000	39.9	200	201	
	SA				43.6		226	
	SH				44.0		226	
Humes et al. (1983)	SA	Avgerage 4.2	Red Poll, Gelbvieh, Charolais		33.6		196	
	SH				33.5		190	
Thompson et al. (1983)	HA		Red Poll		29.5	205	188	
	SA				33.0		211	

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[a] A=Angus, H=Hereford, S=Simmental, B=Brown Swiss and J=Jersey.

TABLE III

CHARACTERIZATION OF TWO-BREED CROSS COWS: COW WEIGHT AND MILK PRODUCTION

Source	Cow Breed Type[a]	Cow Age at Calving, Years	Calf Sire Breed	No. Cows	Cow Weight, Kg	24-Hour Milk Yield No. Cows	24-Hour Milk Yield Kg
Laster et al. (1976)	HA, AH	1.5		132	325		
	SA, SH			157	349		
	JA, JH			117	298		
Notter et al. (1978a)	HA, AH	2	Hereford, Angus, Brahman, Devon, Holstein			10	4.4
	SA, SH					10	4.7
	JA, JH					10	5.2
	HA, AH	3	Hereford, Chianina, Maine-Anjou, Angus, Gelbvieh			36	5.6
	SA, SH					18	8.0
	JA, JH					17	8.8
Belcher and Frahm (1979)	HA, AH	2	Red Poll, Shorthorn	78	322[b]	8	4.35
	SA			50	359[b]	8	6.63
	SH			24	338[b]	8	5.57
	BA			40	341[b]	8	7.57
	BH			36	328[b]	8	7.44
	JA			52	300[b]	8	6.94
	JH			54	301[b]	8	6.49
Bowden (1980)	HA	2	Red Poll	23	396[b]	23	5.9
	SA			28	425[b]	28	6.6
	JA			21	370[b]	21	6.7

TABLE III (Continued)

Source	Cow Breed Type[a]	Cow Age at Calving, Years	Calf Sire Breed	No. Cows	Cow Weight, Kg	24-Hour Milk Yield	
						No. Cows	Kg
Chenette and Frahm (1981)	HA	4	Charolais, Limousin			9	6.35
	AH					9	6.68
	SA					9	7.37
	SH					8	6.94
	BA					9	7.94
	BH					9	7.53
	JA					9	8.23
	JH					9	7.68
Long et al. (1981)	HA, AH	First 3 Calf Crops			442		
	JA, AJ				399		
	JH, HJ				388		
Humes and Taylor (1983)	SA	5-7	Red Poll, Gelbvieh, Charolais			Total of 95	8.4
	SH						8.4
Gaskins and Anderson (1980)	AH	2-4				18	5.8
	SA					19	7.7
	JA					18	7.7

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[a] A=Angus, H=Hereford, S=Simmental, B=Brown Swiss and J=Jersey.

[b] Weights taken postcalving and at weaning were averaged.

TABLE IV

CHARACTERIZATION OF TWO-BREED CROSS COWS: POSTWEANING FEEDLOT PERFORMANCE OF CALVES

Source	Cow Breed Type[a]	Cow Age at Calving, Years	Calf Sire Breed	No. Calves	200-Day Weight, Kg	Average Daily Gain, Kg/Day	452-Day Weight, Kg	Feed Efficiency,[b] Kg/Kg
Young et al. (1978)	HA, AH	2	Hereford, Angus, Brahman, Devon, Holstein	39	172	1.07	440	
	SA, SH			63	186	1.05	451	
	JA, JH			44	186	.98	433	
Restle et al. (1983)[c]	AA		Diallel Mating	Total of 132				5.63
	BB							6.73
	BA, AB							6.29

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[a] A=Angus, H=Hereford, Simmental, B=Brown Swiss and J=Jersey.

[b] Feed Efficiency=Dry matter intake (kg) / live weight gain (kg).

[c] Calves slaughtered at constant external fat.

TABLE V

CHARACTERIZATION OF TWO-BREED CROSS COWS: CALF CARCASS TRAITS

Source	Cow Breed Type[a]	No. Calves	Slaughter Weight, Kg	Carcass Weight, Kg	Fat Thickness, Cm	*Longissimus* Area, Cm^2	Estimated KHP Fat, %
Young et al. (1978)[bc]	HA, AH	37	455	274	1.21	66.5	2.97
	SA, SH	62	464	280	.89	71.6	2.63
	JA, JH	41	448	269	1.15	66.5	3.07

Source	Cow Breed Type[a]	Yield Grade	Estimated Retail Product, %[d]	Conformation Score[e]	Marbling Score[f]	Quality Grade[e]
Young et al. (1978)[bc]	HA, AH	3.27	67.9	11.9	11.2	9.7
	SA, SH	2.69	71.1	11.9	10.1	9.0
	JA, JH	3.21	68.3	10.8	10.4	9.4

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[a] A=Angus, H=Hereford, S=Simmental, B=Brown Swiss and J=Jersey.

[b] Cows were 2 years old at time of calving and mated to Hereford, Angus, Brahman, Holstein and Devon bulls.

[c] Means were adjusted to a common slaughter age of 468 days.

[d] Estimated Retail Product (%) = 76.2-6.50(adjusted fat thickness, cm)-.087(*longissimus* area, cm^2) -1.23(estimated KHP fat)-2.34(marbling score).

[e] 10=Choice-, 11=Choice avg, 12=Choice+, etc.

[f] 9=Slight+, 10=Small-, 11=small avg, etc.

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CHAPTER III

PERFORMANCE COMPARISONS AMONG VARIOUS TWO-BREED CROSS COW GROUPS. I. COW PRODUCTIVITY AND CALF PERFORMANCE TO WEANING

Summary

Performance of various two-breed cross cow groups (Hereford X Angus, HA; Angus X Hereford, AH; Simmental X Angus, SA; Simmental X Hereford, SH; Brown Swiss X Angus, BA; Brown Swiss X Hereford, BH; Jersey X Angus, JA and Jersey X Hereford, JH) producing 1721 three-breed cross calves over a 7 yr period was evaluated. Cows ranged in age from 3 to 9 yr and were mated to 2 sire breeds each year (Charolais and Brahman, 2 yr; Charolais and Limousin, 4 yr; Limousin and Gelbvieh, 1 yr). Calves were born in the spring and weaned at an average age of 205 d. Compared to birth weights of calves from HA and AH cows (averaged 36.9 kg), calves from S and B cross cows averaged 2.5 kg heavier, and calves from J cross cows averaged 1.9 kg lighter. Frequency of calving difficulty for SA cows (21.7 %) was greater than for AH, BH and J cross cows (averaged 10.1 %). Weaning rate averaged 81.2 % for J cross cows, 74.2 % for HA, AH, SA and BA cows and 68.9 % for SH and BH cows. Compared to the 205-d weight of calves from HA and AH cows (averaged 214 kg), calves from S, B and J cross cows were 10, 12 and 7 % heavier, respectively. Compared to the average weight of HA and AH cows (421 kg), S cross cows were 8 % heavier, B cross cows were 4 % heavier and J cross cows were 11 % lighter. Jersey cross cows weaned the heaviest calves as a proportion of cow weight or of cow weight$^{.75}$. Calf weaning weight per cow exposed to breeding, a measure of cow productivity, averaged 160 kg/cow for HA and AH cows. Compared to HA and AH, productivity was 7 % greater for SA and BH cows, 13 % greater for BA and JH cows and 17 % greater for JA cows. Stated differences were significant ($p<.05$).

(Key Words: Beef Cattle, Crossbreeding, Cow productivity, Birth traits, Weaning traits)

Introduction

Crossbreeding has become increasingly accepted and recommended for commercial beef production. In addition to potential heterosis benefits from crossbreeding, the wide variety of cattle types currently available allows considerable flexibility in matching complementary breed types to local environmental resources and constraints. Thus, it is important to characterize breed types for an array of performance traits affecting economic merit. Results of research involving breed evaluation and crossbreeding have been summarized by Cundiff (1970), Franke (1980) and Long (1980).

The present study is a portion of a comprehensive research project designed to evaluate lifetime productivity of various two-breed cross cows when mated to bulls of a third breed. Efficient production of weaned calves is an important component contributing to the overall efficiency of producing retail beef. The objective of this study was to evaluate and compare cow productivity and calf performance to weaning of various two-breed cross cow groups. Productivity of these cows as 2-yr-olds was reported by Belcher and Frahm (1979). In addition, samples of these crossbred cow groups have been evaluated for milk production (Chenette and Frahm, 1981) and for nutrient intake and efficiency of weaned calf production (Marshall et al., 1984).

Materials and Methods

Data used in this study were collected from 1976 through 1982. Crossbred females were were produced in 1973, 1974 and 1975 by Angus (A) and Hereford (H) cows mated to H, A, Simmental (S), Brown Swiss (B) and Jersey (J) bulls to produce 8 two-breed cross groups (HA, AH, SA, SH, BA, BH, JA and JH). Development of the cow herd was described in detail by Belcher and Frahm (1979). Two-breed cross heifers were mated to Shorthorn and Red Poll bulls to produce three-breed cross calves at 2 yr of age (Belcher and Frahm, 1979). Data used in the present study were collected from these cows as 3- to 9-yr-olds when mated to relatively larger sire breeds (Table I).

Two sire breeds were used in any one year: Charolais and Brahman for 2 yr, Charolais and Limousin for 4 yr and Limousin and Gelbvieh for 1 yr. The number of bulls of a given sire breed used in a given year ranged from 3 to 9. Some of the Charolais sires were used more than 1 yr. In a given year, each bull was mated to approximately the same number of cows, and bulls were randomly assigned to cows within each crossbred cow group X cow age subclass. Cows were bred predominantly by artificial insemination. Some were bred by natural service in single sire breeding pastures.

Cows were managed on native tall grass and bermudagrass pastures at the Lake Carl Blackwell Research Range near Stillwater. Supplementary praire hay and cottonseed meal were provided as needed in the winter months to meet protein requirements and to assist cows in maintaining condition adequate for rebreeding.

The breeding season lasted approximately 75 d, starting May 1 each year. Thus, calves were born mostly in February and March. Calves remained with their dams with no creep feeding until weaned in the fall at an average age of 205 d. Cows were closely observed during the calving season and each birth was assigned a calving score by the herdsman (1 = no difficulty, 2 = minor assistance without mechanical puller, 3 = moderately difficult pull, 4 = hard pull, 5 = Caesarian birth and 6 = abnormal presentation). Birth data for abnormally presented calves and twins were deleted prior to analysis. At weaning, each calf was weighed and assigned a subjective condition score (1 = very thin to 9 = very fat) and conformation score (13 = average choice). Cows were weighed prior to the start of the breeding season and at weaning.

Calving rate, percent live calves and weaning rate are all based on the number of cows exposed to breeding. Percent live calves born was calculated based on the number of calves alive approximately 24 h after birth. Crossbred cow group means for percent weaned were used as weighting factors for individual 205-d calf weights in calculating kg of weaning weight per cow exposed to breeding. Cows were generally culled for failure to conceive 2 consecutive years or because of serious soundness or disposition problems.

Crossbred cow group means for calving rate, % live calves and weaning rate were calculated within years and then averaged over years. Chi-square values were calculated from two-way contingency tables (Snedecor and Cochran, 1967) to test for differences among crossbred cow groups.

Other traits were analyzed by mixed model least squares procedures described by Harvey (1977, 1982). Full model analyses included calf sire breed (B), crossbred cow group (C), cow age (A) and calf sex (S) as fixed main effects and B X C, B X S, C X A, C X S and A X S interactions. For analysis purposes, cows were classified into 3 age groups: 3-yr-olds, 4-yr-olds and mature (5-9 yr of age). Three of 12 cells were missing for the B X A interaction. However, in previous analyses using subsets of these data, the B X A interaction was not important. Calf birth date was included as a covariate. Three-way interactions were assumed to be nonsignificant. Random nested effects included years within calf sire breed and sires within years and calf sire breed. Sources of variation determined to be unimportant ($p>.10$) from full model analyses of variance were eliminated from the model for a given trait and least squares means were calculated from reduced models. The mean square for sires nested in years and calf sire breed was used to test for significance of sire breed effects. Significance of all other effects were tested using the residual mean square.

Consideration of years within sire breed as a random effect resulted in relatively larger standard errors of least squares means than would have been obtained if years had been considered fixed. However, standard errors of differences between crossbred cow group means are not inflated by year within sire breed variation, with the result being that the standard error of a difference between two crossbred cow groups means is sometimes smaller than either least squares mean standard error. Linear contrasts were constructed to obtain differences and appropriate standard errors of differences among pairs of crossbred cow group least squares means. Differences among means were tested by Duncan's new multiple range test as modified by Kramer (1957).

Results and Discussion

Cow Reproductive Performance. Crossbred cow group means for reproductive traits are presented in Table II. Chi-square values were significant ($p<.01$), indicating that differences exist among crossbred cow groups for calving rate, percent live calves and weaning rate. Calving rate averaged 88.3 % for J cross cows, 81.0 % for HA, AH, SA and BA cows and 73.7 % for SH and BH cows. Percentage of cows producing a live calf 24 h after birth averaged 86.5 % for JA cows, 80.9 % for HA and JH cows, 76.4 % for AH, SA and BA cows and 70.2 % for SH and BH cows. Percentage of cows producing a calf at weaning averaged 81.2 % for J cross cows, 74.2 % for HA, AH, SA and BA cows, and 68.9 % for SH and BH cows. Angus cross cows consistently produced a higher percentage of calves than Hereford cross cows. Excluding the HA and AH groups, calving rate and weaning rate, respectively, averaged 83.2 % and 76.9 % for Angus crosses and 78.1 and 72.3 % for Hereford crosses. The overall reproductive performance of these cows was somewhat lower than expected due to artificial insemination during a restricted breeding season under extensive range conditions.

Cundiff et al. (1984) reported small crossbred cow group differences among 2- through 8-yr-old HA reciprocal, S and J cross cows for calving rates and weaning rates. Crossbred cow group means were also similar among 3 through 7-yr-old HA reciprocal, and B cross cows (Cundiff et al., 1984). Nelson and Beavers (1982) reported similar conception rates for AH and BH cows ranging from 2-7 yr of age.

Cow Weight and Calf Preweaning Traits. Probabilities of attaining greater F-values from full model analyses of variance are presented in Table III. Cow weight was significantly affected by calf sire breed, year within calf sire breed, crossbred cow group, cow age and the calf birth date. Calf sire breed, year within sire breed, sire within year within sire breed and crossbred cow group were significant for all birth and preweaning traits. Cow age significantly affected all traits except calving difficulty and calf weaning condition score. Calf sex approached significance for weaning condition score and was highly significant for all other birth and preweaning traits. The sire breed X crossbred cow group interaction was significant for weaning condition score. The crossbred cow group X cow age interaction approached significance for cow weight, calf birth weight, calf 205-d weight and weaning conformation score. The cow age X calf sex interaction was significant for average daily gain and calf 205-d weight. The linear effect of calf birth date was significant for average daily gain, calf 205-d weight and both weaning scores.

Cow weights, calf birth weights and calf weaning weights are presented by crossbred cow group and cow age in Table IV. The dam age X crossbred cow group subclass least squares means for cow weight indicate that J cross cows reached a higher proportion of their mature weight at an earlier age relative to the other cow breed types evaluated. Three-year-old cow weight as a percentage of mature weight averaged 87.8, 88.4, 88.1 and 94.4 % for HA and AH, S, B and J cross cows, respectively. This helps explain the higher relative weights at birth and weaning of calves from J cross cows at younger ages. Weights of these cows at 2 yr of age (Belcher and Frahm, 1979) as a percentage of mature cow weight averaged 71.9, 72.7, 72.3 and 78.6 % for HA and AH reciprocal, S, B and J cross cows, respectively.

Birth weights of calves from J cross cows were heavier, relative to other crossbred dam groups, among 3- and 4-yr-old dams than among mature dams. Using the average of HA and AH as a base, ratios for calf birth weight for HA and AH reciprocal, S, B and J crosses, respectively, averaged 100, 106, 106 and 97 among 3-yr-old cows; 100, 106, 111 and 96 among 4-yr-old cows; and 100, 106, 105 and 91 among mature cows.

Similar to the pattern of the crossbred cow group X cow age interaction for birth weight, 205-d weights of calves from J cross cows were higher relative to other crossbred cow groups when the cows were 3 and 4 yr of age than when the cows were of mature ages. Ratios for weaning weights of calves from HA and AH reciprocal cross, S, B and J cross cows, respectively, averaged 100, 109, 111 and 109 among 3-yr-old cows; 100, 112, 114 and 107 among 4-yr-old cows; and 100, 110, 113 and 104 among mature cows. For these same cows as 2-yr-olds, Belcher and Frahm (1979) reported calf 205-d weights of 168, 190, 198 and 189 kg (ratios were 100, 113, 118 and 113) for calves from A and H reciprocal, S, B and J cross cows, respectively. For calves out of HA and AH, S cross and J cross cows, respectively, U. S. Meat Animal Center researchers reported weaning weights of 164, 181 and 181 kg (ratios were 100, 110 and 110) among 2-yr-old cows, 188, 206 and 196 kg (ratios were 100, 110 and 104) among 3-yr-old cows (Notter et al., 1978b) and 229, 250 and 235 kg (ratios were 100, 109 and 102) among 4- through 8-yr-old cows (Cundiff et al., 1981).

Crossbred cow group least squares means for cow weight, calf birth weight and calving difficulty are presented in Table V. Averaged over ages in the present study, HA cows were 17 kg heavier than AH cows. Compared to the average of HA and AH cows (421 kg), S cross cows were 34 kg (8 %) heavier, B cross cows were 15 kg (4 %) heavier and J cross cows were 48 kg (11 %) lighter in weight. Bowden (1980) reported 2-yr-old cow weights of 396, 425 and 370 kg for HA, SA and JA cows, respectively (average of weights taken at calving and at weaning). For cows ranging from 2-8 yr of age, Cundiff et al. (1984) reported 5 % heavier weights for S cross cows and 13 % lighter weights for J cross cows than for HA reciprocal cross cows. For cows ranging from 2-7 yr of age, Cundiff et al. (1984) reported weights of 561 and 569 kg, respectively, for HA reciprocal and B cross cows (difference was 1.4 %).

Calves from HA cows were 2 kg heavier at birth than calves from AH cows. Compared to the average birth weight of calves from HA and AH cows (36.9 kg), calves from S and B cross cows averaged 2.5 kg heavier, and calves from J cross cows averaged 1.9 kg lighter in weight. Results for birth weights from this study are in close agreement with those reported by Notter et al. (1978a) and Cundiff et al. (1984) for H and A reciprocal cross, S cross and J cross cows, Bowden (1980) for HA, SA and JA cows, Fredeen et al. (1982) for HA and S cross cows and Nelson and Beavers (1982) and Cundiff et al. (1984) for AH and BH cows.

Frequency of calving difficulty for SA cows (21.7 %) was greater than for AH, BH and J cross cows (averaged 10.1 %). The only other significant ($p<.05$) difference was between HA (17.4 %) and JA (7.2 %) cows. Crossbred cow group rankings for calving score were similar to those for percentage of calving difficulty. In the cattle germ plasm study at the U. S. Meat Animal Research Center, a higher incidence of calving difficulty was reported for H and A reciprocal cross and S cross cows than for J cross cows, especially for 2-yr-olds (Notter et al., 1978a; Cundiff et al., 1981; Cundiff et al., 1984). Nelson and Beavers (1982) reported 21.8 and 6.7 % assisted births for AH and BH cows, respectively, when adjusted for effects of calf birth weight and dam weight. However, unadjusted mean percentage assisted births for AH (23.1 %) and BH (18.9 %) were not significantly different. Cundiff et al. (1981) reported a higher incidence of calving difficulty for HA and AH cows than for B cross cows as 2-yr-olds, but crossbred group differences were quite small among cows ranging from 3-7 yr of age.

Least squares means for average daily gain, weaning weight and weaning scores are presented in Table VI. Calves from HA cows had the slowest rate of gain from birth to weaning (853 g/d) and were exceeded by calves from AH cows (874 g/d), SH and J cross cows (averaged 939 g/d), SA cows (967 g/d) and B cross cows (averaged 985 g/d). Calf

205-d weights of calves from S, B and J cross cows exceeded those of calves from HA and AH cows (averaged 214 kg) by 21, 26 and 14 kg (10, 12 and 7 %), respectively. Bowden (1980) reported weaning weights of 219, 235 and 222 kg for calves from HA, SA and JA cows, respectively. Cundiff et al. (1981) reported 27 kg heavier weaning weights for calves from B cross cows than for calves from HA and AH cows. Fredeen et al. (1982) reported 25 kg heavier weaning weights for calves out of S cross cows than for calves out of HA cows. Nelson et al. (1982) reported that BH cows weaned calves 30 kg heavier than calves weaned by AH cows.

Calves were quite uniform at weaning with respect to condition scores (averaged 13.4 overall, $p>.05$). Weaning conformation scores ranged from 13.8 for calves from S cross cows to 13.0 for calves from J cross cows.

Estimates of Cow Productivity. Effects of sire breed, year within sire breed, crossbred cow group, cow age and calf sex were significant ($p<.01$) for all traits listed in Table VII. Variation among sires within year within sire breed approached significance ($p<.06$) for all traits. The cow age X calf sex interaction was significant ($p<.02$) for kg calf 205-d weight per cow exposed.

Least squares means for cow productivity traits are shown in Table VIII. Ratios of calf weight to cow weight or to cow metabolic weight (cow weight$^{.75}$) have often been calculated in studies as estimators of efficiency, but may be biased in favor of smaller cows (Dinkel and Brown, 1978). Based on the ratio of 205-d calf weight to cow weight, J crosses weaned the greatest percent of cow weight (61.9 %), followed by B crosses (averaged 55.7 %), AH and S crosses (averaged 52.4 %) and HA (50.3 %). Using the average of HA and AH as a base, the calf weaning weight to cow weight ratios for S crosses were similar, and those for B and J crosses were 8 and 20 % greater, respectively. Crossbred cow group rankings were similar when the ratio included cow weight$^{.75}$ versus cow weight, although SA cows had a significantly higher ($p<.05$) ratio than AH cows for the former (2.42 versus 2.36 kg/kg$^{.75}$) but not for the latter (.527 versus .526 kg/kg). Similar rankings of crossbred cow groups were reported for these cows as 2-yr-olds (Belcher and Frahm, 1979). Bowden (1980) also reported higher ratios for JA cows than for HA or SA cows (HA and SA had similar ratios) based on calf weaning weight as a percentage of dam's weight postcalving and at weaning.

Cow productivity, measured as kg calf 205-d weight per cow exposed to breeding was 2.5 % greater for HA cows than for AH cows. Exceeding the average of HA and AH reciprocal crosses (160 kg/cow) in productivity were SA and BH cows by 11 kg (7 %), BA and JH cows by 21 kg/cow (13 %) and JA cows by 27 kg (17 %). Cundiff et al. (1984) reported 8 and 4 % greater calf weaning weight per cow exposed for S and J cross cows, respectively, than for HA reciprocal crosses among 2- through 8-yr-old cows. Cundiff et al. (1984) reported 14 % greater productivity for b cross cows than for HA reciprocal crosses among 2- through 7-yr-old cows.

Marshall et al. (1984) reported cow-calf intake of total digestible nutrients (TDN) and conversion of TDN to calf weaning weight of smaller samples of the crossbred cows evaluated in the present study. Although differences among crossbred cow groups were generally not significant, conversions ranged from an average of 10.0

kg TDN per kg calf weight for JH, SH and BH groups to 10.9 kg/kg for JA and SA groups. Inconsistency in crossbred cow group rankings among various estimators of efficiency suggests that nutrient requirements, reproductive performance and calf weights need to be considered simultaneously to accurately estimate net efficiency of calf production. The high cost of individual cow feeding is an unfortunate limitation in this respect.

Conclusions. These data indicate that important differences in cow and calf productivity exist among the two-breed cross cow groups evaluated. Because of apparent differences in rate of physiological maturity, the relative magnitude of differences among crossbred cow group means for some traits may vary depending on the ages of cows evaluated. While it is important to characterize levels of performance of breed types for various individual traits, simultaneous evaluation of economically important traits is needed to accurately determine net worth of a breed type for use in commercial beef production.

TABLE I

EXPERIMENTAL DESIGN[a]

Year of calf birth	Cow age(s)	Sire breeds	No. sires[b]
1976	3	Charolais	4
		Brahman	3
1977	3, 4	Charolais	9(3)
		Brahman	3
1978	3, 4, 5	Charolais	8(4)
		Limousin	8
1979	4, 5, 6	Charolais	8(3)
		Limousin	8
1980	5, 6, 7	Charolais	8(4)
		Limousin	8
1981	6, 7, 8	Charolais	8(6)
		Limousin	8
1982	7, 8, 9	Limousin	7
		Gelbvieh	7

[a] Each crossbred cow group (Hereford X Angus, Angus X Hereford, Simmental X Angus, Simmental X Hereford, Brown Swiss X Angus, Brown Swiss X Hereford, Jersey X Angus and Jersey X Hereford) and calf sex (steer and heifer) was represented in each sire, cow age and year.

[b] Number in parentheses is the number of sires previously used.

TABLE II

COW REPRODUCTIVE PERFORMANCE

Crossbred cow group[a]	% calves born[b]	% live calves[b]	% calves weaned[b]
HA	83.0	80.2	76.1
AH	81.0	76.6	73.2
SA	81.1	75.9	72.5
SH	73.8	69.3	67.9
BA	78.7	76.7	75.0
BH	73.6	71.1	69.8
JA	89.7	86.5	83.2
JH	86.8	81.6	79.2
Chi-square	40.0**	40.9**	30.9**

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[b] Based on number of cows exposed to breeding.

** P<.01.

TABLE III

PROBABILITIES OF ATTAINING GREATER F-VALUES FROM FULL MODEL ANALYSES OF VARIANCE FOR COW WEIGHT AND CALF PREWEANING TRAITS

			Calf Traits						
		Cow	Birth	Calving difficulty		Avg daily	Weaning	Weaning scores	
Source	df[a]	wt	wt	Score	%	gain	wt	Condition	Conformation
Calf sire breed (B)	3	.01	.01	.01	.01	.01	.01	.01	.01
Year (Y)/B	10	.01	.01	.01	.01	.01	.01	.01	.01
Sire/Y/B	84	.53	.01	.01	.01	.02	.01	.01	.01
Crossbred cow group (C)	7	.01	.01	.03	.01	.01	.01	.05	.01
Cow age (A)	2	.01	.01	.10	.30	.01	.01	.66	.01
Calf sex (S)	1	.87	.01	.01	.01	.01	.01	.07	.01
B X C	21	.80	.85	.11	.09	.96	.98	.01	.14
B X S	3	.38	.17	.23	.14	.93	.89	.60	.85
C X A	14	.08	.01	.36	.24	.15	.06	.32	.01
C X S	7	.68	.62	.16	.18	.33	.47	.22	.32
A X S	2	.33	.36	.20	.14	.02	.01	.41	.47
Birth date	1	.01	.46	.85	.57	.02	.01	.01	.01
Remainder	1565(1468)								

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[a] First number is degrees of freedom for birth traits; number in parentheses is degrees of freedom for cow weight and preweaning traits.

TABLE IV

LEAST SQUARES MEANS FOR COW WEIGHT, CALF BIRTH WEIGHT AND WEANING WEIGHT BY CROSSBRED COW GROUP AND COW AGE

Crossbred Cow Group[a]	No. calves Born	Cow wt, kg Cow age group			Calf birth wt, kg Cow age group			Calf weaning wt, kg Cow age group		
		3	4	Mature	3	4	Mature	3	4	Mature
HA	210	406	427	453	36.8	38.0	38.9	208	213	217
AH	205	380	413	442	34.0	35.2	38.6	203	217	222
SA	242	426	459	478	37.1	39.0	40.7	227	239	242
SH	176	422	462	481	38.2	38.9	41.6	221	243	239
BA	189	406	431	459	36.9	39.4	39.9	227	241	248
BH	171	409	444	466	37.8	41.8	41.8	229	249	246
JA	272	362	373	379	33.4	35.4	34.6	224	231	226
JH	256	360	378	386	35.4	34.9	35.9	224	231	230
Overall	1721	396	423	443	36.2	37.8	39.0	220	233	234
Avg S.E. of mean		12.6	12.6	10.6	1.15	1.16	.90	8.3	8.3	7.7

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

TABLE V

LEAST SQUARES MEANS FOR COW WEIGHT, CALF BIRTH WEIGHT AND CALVING DIFFICULTY

Crossbred cow group[a]	No. calves born	Cow wt kg	Cow wt % HA, AH	Calf Birth wt kg	Calf Birth wt % HA, AH	Calving difficulty[b] Score	Calving difficulty[b] %
HA	210	429^{e}	102.0	37.9^{f}	102.7	1.53^{de}	17.4^{de}
AH	205	412^{f}	98.0	35.9^{g}	97.3	1.36^{def}	10.2^{ef}
SA	242	454^{d}	108.0	38.9^{ef}	105.4	1.58^{d}	21.7^{d}
SH	176	455^{d}	108.2	39.6^{de}	107.3	1.45^{def}	13.9^{def}
BA	189	432^{e}	102.7	38.7^{ef}	104.9	1.40^{def}	15.7^{def}
BH	171	440^{e}	104.6	40.4^{d}	109.5	1.29^{ef}	9.5^{ef}
JA	272	371^{g}	88.2	34.5^{h}	93.5	1.29^{f}	7.2^{f}
JH	256	374^{g}	88.9	35.4^{gh}	95.9	1.39^{def}	13.4^{ef}
Overall	1721	421		36.7		1.41	13.6
Avg S.E. of mean		10.3		.87		.104	3.83
Avg S.E. of diff.[c]		5.4		.58		.113	4.40

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[b] 1=No difficulty, 2=little difficulty, 3=moderate difficulty, 4=major difficulty and 5=caesarian. A score of 3 or more was considered a difficult birth.

[c] Average standard error of difference between pairs of means.

[defgh] Means in the same column not sharing a common superscript differ ($p<.05$).

TABLE VI

LEAST SQUARES MEANS FOR CALF AVERAGE DAILY GAIN, WEANING WEIGHT AND WEANING SCORES

Crossbred cow group[a]	No. calves weaned	Avg daily gain g/d	Avg daily gain % HA, AH	Weaning wt kg	Weaning wt % HA, AH	Weaning scores Condition[b]	Weaning scores Conformation[c]
HA	198	853^{i}	98.8	213^{h}	99.8	5.0	13.2^{i}
AH	196	874^{h}	101.2	214^{h}	100.2	5.1	13.4^{h}
SA	221	967^{f}	112.0	236^{ef}	110.5	5.1	13.8^{e}
SH	165	948^{g}	109.8	234^{f}	109.6	5.1	13.8^{ef}
BA	183	988^{e}	114.4	239^{ef}	111.9	5.0	13.6^{g}
BH	165	981^{ef}	113.6	241^{e}	112.9	4.9	13.6^{fg}
JA	254	930^{g}	107.7	227^{g}	106.3	5.1	12.9^{j}
JH	242	938^{g}	108.6	228^{g}	106.8	5.1	13.0^{j}
Overall	1624	935		229		5.0	13.4
Avg S.E. of mean		34.5		7.6		.11	.23
Avg S.E. of diff.[d]		9.1		2.5			.08

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[b] Condition score equivalents: 1=very thin to 5=moderate to 9=very fat.

[c] Conformation score equivalents: 12=low choice, 13=avg choice and 14= high choice.

[d] Average standard error of difference between pairs of means.

[efghij] Means in the same column not sharing a common superscript differ ($p<.05$).

TABLE VII

PROBABILITIES OF ATTAINING GREATER F-VALUES FROM FULL MODEL ANALYSES OF VARIANCE FOR COW PRODUCTIVITY TRAITS

Source	df	Calf weaning wt/ Cow wt	Calf weaning wt/ Cow wt$^{.75}$	Calf weaning wt Per cow exposed
Calf sire breed (B)	3	.01	.01	.01
Year (Y)/B	10	.01	.01	.01
Sire/Y/B	84	.06	.01	.01
Crossbred cow group (C)	7	.01	.01	.01
Cow age (A)	2	.01	.01	.01
Calf sex (S)	1	.01	.01	.01
B X C	21	.91	.94	.96
B X S	3	.85	.88	.79
C X A	14	.98	.89	.25
C X S	7	.12	.10	.27
A X S	2	.73	.42	.02
Birth date	1	.68	.79	.01
Remainder	1468			

TABLE VIII

LEAST SQUARES MEANS FOR MEASURES OF COW PRODUCTIVITY

Crossbred cow group[a]	No. calves weaned	Calf weaning wt/cow wt		Calf weaning wt/cow wt$^{.75}$		Calf weaning wt per cow exposed	
		kg/kg	% HA, AH	kg/kg	% HA, AH	kg/kg	% HA, AH
HA	198	.503f	97.8	2.28g	98.3	162f	101.3
AH	196	.526e	102.2	2.36f	101.7	158g	98.8
SA	221	.527e	102.4	2.42e	104.3	172e	107.5
SH	165	.519e	100.9	2.39ef	103.0	159fg	99.4
BA	183	.559d	108.6	2.54d	109.5	181d	113.1
BH	165	.554d	107.7	2.52d	108.6	169e	105.6
JA	254	.620c	120.5	2.70c	116.4	187c	116.9
JH	242	.617c	119.9	2.70c	116.4	180d	112.5
Overall	1624	.553		2.49		171	
Avg S.E. of mean		.011		.054		5.58	
Avg S.E. of diff.[b]		.0061		.024		1.50	

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[b] Average standard error of difference between pairs of means.

[cdefg] Means in the same column not sharing a common superscript differ ($P<.05$).

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CHAPTER IV

PERFORMANCE COMPARISONS AMONG VARIOUS TWO-BREED CROSS COW GROUPS. II. FEEDLOT PERFORMANCE OF THREE-BREED CROSS CALVES

Summary

Over a 7 yr period, feedlot data were collected on 1514 three-breed cross steers and heifers produced by Hereford X Angus (HA), Angus X Hereford (AH), Simmental X Angus (SA), Simmental X Hereford (SH), Brown Swiss X Angus (BA), Brown Swiss X Hereford (BH), Jersey X Angus (JA) and Jersey X Hereford (JH) cows mated to Charolais, Brahman, Limousin and Gelbvieh bulls. Calves entered the feedlot each year at weaning and were fed to an anticipated low choice carcass grade. Compared to calves from HA and AH cows (averaged 216 kg), initial weights were heavier for calves from S, B and J cross cows by 10, 12 and 6 %, respectively. Compared to the average slaughter weight of calves from HA and AH cows (500 kg), calves from S and B cross cows were 9 % and 6 % heavier, respectively, and calves from J cross cows averaged 4 % lighter (calves from JH were 3 % heavier than from JA cows). For the entire feeding period, average daily gains for calves from HA, AH, S and B cross cows (averaged 1.145 kg/d) exceeded that of calves from J cross cows by 8 %. Daily gains of calves from S cross cows exceeded gains of calves from HA cows by 4

%. Calves from S cross, BH and HA cows were on feed an average of 261 d, followed by calves from BA, AH and JH (averaged 248 d) and JA (237 d). Feed intake was measured on a pen basis (calves were penned by crossbred cow group, sire breed and sex) for the last 5 yr of the study. Compared to the average daily feed intake of calves from HA and AH cows (8.38 kg/d), calves from BA cows consumed 9 % more and from S cross and BH 5 % more feed per d. Feed conversion favored calves from HA and AH cows (7.43 kg feed/kg gain) over calves from SA, BA and JH cows by an average of 5 % and calves from JA cows by 7 %. Stated differences were significant ($p<.05$).

(Key Words: Beef cattle, Crossbreeding, Feedlot).

Introduction

This study is one of a series designed to evaluate and compare lifetime productivity of two-breed cross cows when mated to bulls of a third breed. A previous paper (Frahm and Marshall, 1985) characterized cow productivity and calf preweaning performance for these cows. Evaluation of cow breed types for use in commercial beef production should be based on a wide spectrum of important production traits. Thus, the objective of this study was to evaluate feedlot performance of three-breed cross calves from various two-breed cross cow groups when fed a finishing ration from weaning to a low choice carcass grade.

Materials and Methods

Feedlot data were collected on 1514 three-breed cross calves (771 heifers and 743 steers) over a 7 yr period. The calves were born in the spring (1976-82) from Hereford X Angus (HA), Angus X Hereford (AH), Simmental X Angus (SA), Simmental X Hereford (SH), Brown Swiss X Angus (BA), Brown Swiss X Hereford (BH), Jersey X Angus (JA) and Jersey X Hereford (JH) cows mated to Charolais, Brahman, Limousin and Gelbvieh bulls (only two sire breeds were used in a given year). Although dam ages ranged from 3 to 9 yr, cows were classified into 3 age groups for analysis purposes: 3-yr-olds, 4-yr-olds and mature (5-9 yr of age). Development of the cow herd (Belcher and Frahm, 1979) and subsequent terminal cross mating design (Frahm and Marshall, 1985) have been previously described.

Calves were reared with their dams on native tall grass and bermudagrass pastures at the Lake Carl Blackwell Research Range west of Stillwater. Calves were born mostly during February and March and were weaned in October at an average age of 205 d. Immediately after weaning, calves were transported to feedlot facilities at the Southwestern Livestock & Forage Research Station near El Reno, Ok.

Calves were ad libitum fed the diet shown in Table I. Feed intake data were available for the last 5 yr of the study when calves of a given three-breed cross and sex were fed together in a randomly assigned pen. Feed intake was measured by pen, and thus pen was the experimental unit for feed intake and feed conversion. Feeding facilities consisted of two pole barns open to the south, each with 14 concrete floored pens. Each pen was 11.0 m wide X 14.3 m long with

6.4 m of length under roof. Because of the limited number of pens, contemporary calves from HA and AH reciprocal crosses were combined into a single pen.

Based on visual and hands-on appraisal of finish, calves were individually removed from the feedlot for slaughter when an anticipated low choice carcass grade was attained. During the time the cattle were being slaughtered, cattle were weighed and appraised for finish and selected individuals sent to slaughter at two week intervals.

The actual weaning weight was used as the initial feedlot weight. A shrunk weight (final weight) was obtained on each animal prior to shipment. Average daily gain was calculated separately for the first 120 d on test, after 120 d and for the overall feedlot test period. Final age was the age of the calf when the final live weight was obtained.

Weights, gains, final age and days on feed were analyzed by least squares mixed model prodecures (Harvey, 1977; 1982). Fixed effects included in full model analyses were calf sire breed (B), crossbred cow group (C), cow age (A) and calf sex (S) as main effects, and B X C, B X S, C X A, C X S and A X S interactions. Three of 12 cells were missing for the B X A interaction. However, in previous analyses of subsets of these data, the B X A interaction was not significant and therefore not included in the model. Higher order interactions were assumed nonsignificant. Calf age at the start of the feedlot phase (initial age) was included as a covariate for each of these traits, while marbling score was included as a covariate for each trait except initial weight and daily gain during the first 120 d on test.

Included as random nested effects were year within calf sire breed and sire within year within calf sire breed. The mean square for sire within year within sire breed was used to test for significance of sire breed effects. Significance of other effects were tested using the remainder mean square.

Consideration of years within sire breed as a random effect resulted in relatively larger standard errors of least squares means than would have been obtained if years had been considered fixed. However, standard errors of differences between crossbred cow group means are not inflated by year within sire breed variation. Thus, the standard error of a difference between two crossbred cow groups means is sometimes smaller than either least squares mean standard error. Linear contrasts were constructed to obtain differences and appropriate standard errors of differences among pairs of crossbred cow group least squares means.

Feed intake and feed conversion were analyzed by least squares prodedures using a fixed effects model. Effects included in full model analyses were crossbred cow group, year, calf sex and all 2-way interactions. Significance of all effects were tested using the remainder mean square. Since feed intake was measured on a pen basis, subclass numbers were balanced for intake and conversion. Since contemporary calves from HA and AH cows were fed in the same pen, there were only 6 degrees of freedom for crossbred cow group in the analyses of feed intake and feed conversion (compared to 7 degrees of freedom for other traits).

Sources of variation determined to be unimportant (p>.10) from full model analyses of variance were eliminated from the model for a given trait, and crossbred cow group least squares means were calculated from reduced model analyses. Differences among pairs of crossbred cow group least squares means were tested by Duncan's new multiple range test as modified by Kramer (1957).

Results and Discussion

Weights, Gains, Final Age and Days on Feed. Probabilities of attaining greater F-values from full model analyses of variance for these traits are presented in Table II. The effects of sire breed, crossbred cow group, year within sire breed and sire within year within sire breed were highly significant for all traits. Calf sex approached significance for final age ($p<.10$) and was significant for all other traits. Cow age was a significant source of variation for initial weight and days on feed. The sire breed X crossbred cow group interaction was significant for days on feed. The sire breed X calf sex interaction was significant for overall daily gain and final weight. The dam age X calf sex interaction was significant ($p<.01$) for initial weight, final weight, daily gain after 120 d and overall daily gain. The effect of initial age was significant for all traits and the effect of marbling score was significant for final weight, final age and days on feed.

Least squares means are presented for these traits by crossbred dam group in Table III. Initial weights of calves from HA and AH cows (averaged 216 kg) were exceeded by weights of calves from S, B and J cross cows by 22.5, 26.0 and 12.0 kg (10, 12 and 6 %), respectively. Compared to the average final live weight of calves from HA and AH cows (averaged 500 kg), calves from S and B cross cows were 46 kg (9

%) and 30 kg (6 %) heavier, respectively, and calves from J cross cows averaged 21 kg (4 %) lighter. Calves from JH cows were 12 kg (3 %) heavier at slaughter than calves from JA cows. Young et al. (1978) reported postweaning performance (from 200 to 452 d of age) of steer calves out of 2-yr-old HA, AH, SA, SH, JA and JH cows, mated to Hereford, Angus, Brahman, Devon and Holstein bulls. Calves from both J and S cross cows were 14 kg heavier ($p<.05$) than calves from HA and AH cows at 200 d of age. At 452 d of age, calves from S and J cross cows, respectively, were 11 kg heavier and 7 kg lighter (both nonsignificant), than calves from HA and AH cows (S differed from J, $p<.05$).

For the first 120 d on feed, daily gains were similar for calves from AH, SA and SH cows (averaged 1.27 kg/d), exceeding gains of calves from HA and J cross cows by .05 and .14 kg/d, respectively. Calves from HA and B cross cows (averaged 1.24 kg/d) gained .11 kg/d faster than calves from J crosses. After 120 d on feed, there was relatively less variation in daily gains among crossbred cow groups. Gains were similar for calves from HA, AH, S and B cross cows (averaged 1.05 kg/d) and exceeded gains of calves from JA cows by .09 kg/d. Calves from SA, SH and BH cows gained faster than calves from JH cows (1.06 vs 1.00 kg/d).

Over the entire feedlot period, daily gains of calves from HA, AH, S and B cross cows (averaged 1.145 kg/d) exceeded gains of calves from J cross cows by .085 kg/d (8 %). Calves from S cross cows gained .04 kg/d (4 %) faster than calves from HA cows. In the study reported by Young et. al (1978), daily gains of steers from HA, AH and S cross cows averaged 1.06 kg/d compared to .98 kg/d for steers from J cross cows ($p<.05$). USMARC Progress Report No. 6 (1978) reported slightly faster gains (1.13 vs 1.10 kg/d) for steers from B cross cows than for steers from HA reciprocal cross cows (steers were sired by Hereford, Angus, Brangus and Santa Gertrudis bulls).

Relative to other crossbred cow groups, postweaning growth rates of calves from J cross cows were less than preweaning growth rates (Frahm and Marshall, 1985). This likely reflects the effects of high milk producing ability relative to mature size of the Jersey crosses (Chenette and Frahm, 1981). Young et al. (1978) reported that J and S cross cows had higher levels of milk production (Notter et al., 1978) but negative maternal effects on postweaning average daily gain, expressed as deviations from the HA, AH mean.

Averaged over all crossbred cow groups, calves were on feed 253 d and were slaughtered at 461 d of age. Calves from S cross, BH and HA cows were fed an average of 261 d, followed by calves from AH, BA and JH cows (averaged 248 d) and calves from JA cows (237 d). Calves from HA cows were 9 d older at slaughter than calves from AH cows. Compared to the average final age of calves from HA and AH cows (462 d), calves from S cross cows were 11 d older, calves from B cross cows were similar in age and calves from J cross cows were 13 d younger.

Feed Intake and Feed Conversion. Results of F-tests from full model analyses of variance for daily feed intake and feed conversion are presented in Table IV. Calf sire breed significantly affected feed intake, while crossbred cow group, year and sex significantly affected feed intake and conversion. The sire breed X year interaction was significant for feed conversion.

Least squares means for feed intake and conversion are presented by crossbred cow group in Table V. Compared to the daily feed intake of calves from HA and AH cows (8.38 kg/d), calves from BA cows consumed .77 kg/d (9 %) more, calves from S cross and BH cows consumed .46 kg/d (5 %) more and calves from J cross cows had similar intakes (8.24 kg/d). Compared to feed conversion of calves from HA and AH cows (7.43 kg feed/ kg gain), calves from SA, BA and JH consumed .37 kg (5 %) more feed per kg gain and calves from JA cows consumed .54 kg (7 %) more feed per kg gain. Calves from SH and BH were intermediate in feed conversion (averaged 7.63 kg feed/ kg gain) and differed significantly ($p<.05$) from BA and JA. Excluding the HA and AH groups, calves from H cross cows consumed .16 kg (2 %) less feed per kg gain than calves from A cross cows. Restle et al. (1983) reported significant breed of dam effects for feed efficiency of 132 steers out of A, B and F_1 cows (respective means were 5.63, 6.73 and 6.29 kg dry matter per kg gain).

Conclusions. Important differences exist among crossbred cow groups evaluated in this study with respect to calf feedlot performance. Relative to the other crossbred cow groups, postweaning growth rate of J cross calves was inferior to their preweaning growth, while the opposite was true for calves from HA and AH cows. This apparently reflects the effects of cow milk yield relative to potential calf mature size or growth rate. Calves from S and B cross cows performed well, both before and after weaning, with respect to growth rate.

TABLE I

COMPOSITION OF FEEDLOT DIETS

Ingredient	Percent in diet (as fed)	
	1976-78	1979-82
Corn (IFN 4-02-931)	39	78
Milo (IFN 4-04-444)	39	0
Ground alfalfa hay (IFN 1-00-059)	8	8
Cottonseed hulls (IFN 1-01-599)	4	4
Sugarcane molasses (IFN 4-04-696)	5	5
Supplemental pellets[a]	5	5

[a] Supplemental pellets consisted of 67.6% soybean meal (IFN 5-04-604), 12% urea (IFN 5-05-070), 10% calcium carbonate (IFN 6-01-069), 8% salt (IFN 6-04-152), plus Aurofac, Vitamin A and trace minerals.

TABLE II

PROBABILITIES OF ATTAINING GREATER F-VALUES FROM FULL MODEL ANALYSES OF VARIANCE FOR FEEDLOT TRAITS

Source	df[a]	Initial wt	Final wt	Average daily gain			Final age	No. days on feed
				1st 120 d	After 120 d	Overall		
Calf sire breed (B)	3	.01	.01	.01	.01	.01	.01	.01
Year (Y)/B	10	.01	.01	.01	.01	.01	.01	.01
Sire/Y/B	84	.01	.01	.01	.01	.01	.01	.01
Crossbred cow group (C)	7	.01	.01	.01	.01	.01	.01	.01
Cow age (A)	2	.01	.37	.36	.34	.71	.57	.05
Calf sex (S)	1	.01	.01	.01	.01	.01	.10	.02
B x C	21	.99	.46	.32	.31	.60	.14	.04
B x S	3	.77	.01	.08	.13	.04	.21	.12
C x A	14	.26	.62	.97	.35	.77	.15	.16
C x S	7	.52	.37	.27	.16	.07	.69	.36
A x S	2	.01	.01	.17	.01	.01	.31	.51
Initial age	1	.01	.01	.01	.01	.01	.01	.01
Marbling score	(1)		.01		.29	.57	.01	.01
Remainder	1358(1357)							

[a] Number in parentheses represents df for models in which marbling score was included as a covariate.

TABLE III

LEAST SQUARES MEANS FOR FEEDLOT TRAITS

						Average daily gain					
		Initial wt		Final wt		1st 120 d	After 120 d	Overall			
Crossbred cow group[a]	No. calves	Kg	% of HA, AH	Kg	% of HA, AH	Kg/d	Kg/d	Kg/d	% of HA, AH	Final Age, days	No. days fed
HA	175	214^{g}	99.1	501^{e}	100.3	1.22^{d}	1.03^{cd}	1.12^{d}	98.7	466^{de}	258^{cd}
AH	169	218^{g}	100.9	498^{e}	99.7	1.26^{c}	1.04^{cd}	1.15^{cd}	101.3	457^{f}	249^{de}
SA	210	240^{cd}	111.1	544^{c}	108.9	1.27^{c}	1.07^{c}	1.16^{c}	102.2	470^{cd}	263^{c}
SH	161	237^{d}	109.7	547^{c}	109.5	1.28^{c}	1.06^{c}	1.16^{c}	102.2	475^{c}	265^{c}
BA	175	242^{c}	112.0	531^{d}	106.3	1.26^{cd}	1.04^{cd}	1.14^{cd}	100.4	462^{ef}	250^{de}
BH	159	242^{c}	112.0	529^{d}	105.9	1.25^{cd}	1.05^{c}	1.14^{cd}	100.4	463^{def}	259^{cd}
JA	236	226^{f}	104.6	473^{g}	94.7	1.13^{e}	$.96^{e}$	1.05^{e}	92.5	447^{g}	237^{f}
JH	229	230^{e}	106.5	485^{f}	97.1	1.13^{e}	1.00^{de}	1.07^{e}	94.3	450^{g}	246^{e}
Overall	1514	231		513		1.23	1.03	1.12		461	253
Avg S.E. of mean		7.24		9.95		.051	.060	.053		8.07	9.64
Avg S.E. of difference[b]		2.07		4.01		.019	.022	.016		3.48	4.65

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[b] Average standard error of difference between pairs of means.

[cdefg] Means in the same column not sharing a common superscript differ ($P<.05$).

TABLE IV

PROBABILITIES OF ATTAINING GREATER F-VALUES FROM FULL MODEL ANALYSES OF VARIANCE FOR FEED INTAKE AND CONVERSION

Source	df	Daily feed intake	Feed/gain
Calf sire breed (B)	2	.01	.54
Crossbred cow group (C)	6	.01	.02
Year (Y)	4	.01	.01
Calf sex (S)	1	.01	.01
B x C	12	.73	.97
B x Y	3	.25	.01
B x S	2	.76	.16
C x Y	24	.63	.39
C x S	6	.11	.33
Y x S	4	.27	.10
Remainder	75		

TABLE V

LEAST SQUARES MEANS FOR FEED INTAKE AND CONVERSION

Crossbred cow group[a]	No. pens	Daily feed intake		Feed/gain	
		kg/d	% of HA, AH	kg/kg	% of HA, AH
HA, AH	20	8.38[d]	100.0	7.43[b]	100.0
SA	20	8.93[bc]	106.6	7.71[cd]	103.8
SH	20	8.80[c]	105.0	7.60[bc]	102.3
BA	20	9.15[b]	109.2	7.88[de]	106.1
BH	20	8.78[c]	104.8	7.65[bc]	103.0
JA	20	8.25[d]	98.4	7.97[e]	107.3
JH	20	8.23[d]	98.2	7.82[cde]	105.2
Overall	140	8.65		7.72	
S.E. of mean		.093		.075	

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[bcde] Means in the same column not sharing a common superscript differ ($P<.05$).

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CHAPTER V

PERFORMANCE COMPARISONS AMONG VARIOUS TWO-BREED CROSS COW GROUPS. III. CARCASS EVALUATION OF THREE-BREED CROSS CALVES

Summary

Carcasses from 1506 three-breed cross calves produced by Hereford X Angus (HA), Angus X Hereford (AH), Simmental X Angus (SA), Simmental X Hereford (SH), Brown Swiss X Angus (BA), Brown Swiss X Hereford (BH), Jersey X Angus (JA) and Jersey X Hereford (JH) cows mated to Charolais, Brahman, Limousin or Gelbvieh bulls were evaluated over a 7 yr period. Calves were placed in a feedlot at weaning and fed ad libitum a finishing ration until being individually removed for slaughter as each calf attained an estimated low choice carcass grade. *Longissimus* marbling and carcass grade did not vary significantly among crossbred dam groups. Compared to carcass weights for calves from HA and AH cows (averaged 319 kg), carcasses of calves from S, B and J cows, respectively, averaged 9 % heavier, 6 % heavier and 5 % lighter. Carcass weight per d of age was similar for calves from S and B crosses (averaged 738 g/d) and exceeded the average of calves from HA and AH cows by 6 %. External fat thickness of calves from HA and AH cows (averaged 1.51 cm) was .24 cm greater than for calves from S cross and JA cows and .34 cm greater than for calves from BH and JH cows. The average Longissimus area of calves from HA and AH cows ($81.8\ cm^2$), was $4.8\ cm^2$ smaller than that of calves from S cross cows, but $3.7\ cm^2$ larger than that of calves from JA cows. Calves from J cross cows had slightly more estimated KHP fat than did calves from HA and SH cows (3.3 vs 3.1 %). Dressing percentage was greater for calves from AH, SH and BH cows (64.3 %) than for calves from HA and J cross cows (averaged 63.4 %). Stated differences were significant ($p<.05$).

(Key Words: Beef Cattle, Crossbreeding, Carcass).

Introduction

This paper is one of a series reporting evaluation of productivity of various types of two-breed cross cows when mated to terminal cross sires. Preceeding papers characterized crossbred dam groups for the cow-calf (Frahm and Marshall, 1985) and feedlot (Marshall and Frahm, 1985) segments of production. Carcass merit of calves should also be considered when evaluating cow breed types for use in commercial beef production, especially in a terminal crossing sytem in which all calves are slaughtered. Relatively few studies have included both steers and heifers in carcass evaluation of breed types. The objective of this study was to evaluate carcass traits of three-breed cross calves from various two-breed cross cow groups, when calves were fed to a low choice carcass grade.

Materials and Methods

Carcasses from 1506 three-breed cross calves (769 heifers and 737 steers) were evaluated over a 7 yr period. The calves were born in the spring (1976-82) from Hereford X Angus (HA), Angus X Hereford (AH), Simmental X Angus (SA), Simmental X Hereford (SH), Brown Swiss X Angus (BA), Brown Swiss X Hereford (BH), Jersey X Angus (JA) and Jersey X Hereford (JH) cows. Cows ranged in age from 3 to 9 yr and were mated to Charolais, Brahman, Limousin or Gelbvieh bulls (only 2 sire breeds were used in a given year). Development of the cow herd (Belcher and Frahm, 1979) and subsequent terminal cross mating design (Frahm and Marshall, 1985) were described in detail in previous papers.

Following weaning in the fall at an average age of 205 d, the three-breed cross calves were placed in a feedlot and fed a corn or corn-milo finishing ration (Marshall and Frahm, 1985). Based on visual and hands-on appraisal of finish, calves were individually removed from the feedlot upon attaining an estimated low choice carcass grade and sent to a commercial slaughter plant. During the time cattle were being slaughtered, cattle were weighed and appraised for finish and selected individuals were sent to slaughter at 2-wk intervals.

Carcass weight, carcass weight per d of age and dressing percentage were based on hot carcass weight. After a minimum 48-h chill, carcasses were evaluated for marbling (5 = small amount, 6 = modest amount), and were assigned quality grades (9 = high good, 10 = low choice, 11 = average choice) by university personell. External fat thickness was measured at the 12th rib. Kidney, heart and pelvic (KHP) fat was visually estimated. The longissimus muscle surface was traced at the 12th rib interface and the area was measured by use of a planimeter. Percentage of boneless, closely trimmed retail cuts was estimated by the U.S.D.A. cutability equation (Murphey et al., 1960): cutability = 51.34 - 2.277(fat thickness, cm) - .462(KHP fat, %) + .1147(longissimus area, cm^2) - .0205(hot carcass weight, kg).

Crossbred cow group means for % calves weaned (Frahm and Marshall, 1985), calf survival in the feedlot (unpublished data), and production of calf carcass weight were used in the calculation of carcass weight per cow exposed to breeding. Estimated yield of retail lean cuts per cow exposed to breeding was calculated by multiplying the crossbred dam group mean estimated cutability by the crossbred dam group mean carcass weight per cow exposed to breeding.

All traits except carcass weight per cow exposed to breeding and estimated retail cuts per cow exposed to breeding were analyzed by least squares mixed model prodecures (Harvey, 1977; 1982). Full model analyses included the effects listed in Table I. Year nested within calf sire breed, sire nested within year within calf sire breed and remainder error were considered random effects, and other effects were considered fixed. The linear effect of marbling score was not included in analyses of marbling score and carcass grade. Higher order interactions were assumed nonsignificant. The mean square for sire within year within sire breed was used to test for significance of sire breed effects. Significance of all other effects were tested using the remainder mean square.

Consideration of years within sire breed as a random effect resulted in relatively larger standard errors of least squares means than would have been obtained if years had been considered fixed.

However, standard errors of differences between crossbred cow group means are not inflated by year within sire breed variation. Thus the standard error of a difference between two crossbred cow groups means is sometimes smaller than either least squares mean standard error. Linear contrasts were constructed to obtain differences and appropriate standard errors of differences among pairs of crossbred cow group least squares means.

Sources of variation determined to be unimportant ($p>.10$) from full model analyses were eliminated from the model for a given trait, and crossbred cow group least squares means were calculated from reduced model analyses. Differences among crossbred cow group least squares means were tested by Duncan's new multiple range test as modified by Kramer (1957).

Results and Discussion

<u>Carcass Trait Evaluation</u>. Probabilities of attaining greater F-values from full model analyses of variance are presented in Table I. Calf sire breed was a significant source of variation for all traits except marbling score and carcass grade. Year within sire breed was significant for all traits and sire within year within sire breed was significant for all traits except dressing percentage. Crossbred cow group was significant for carcass weight, carcass weight per d of age, <u>longissimus</u> area, fat thickness and estimated KHP fat. Cow age was significant for marbling score and carcass grade. Calf sex was significant for carcass weight, carcass weight per d of age, cutability and <u>longissimus</u> area. Two-way interactions were mostly nonsignificant. The linear effect of initial (feedlot on-test) age

was significant for carcass grade, carcass weight, carcass weight per d of age and longissimus area, and the linear effect of marbling score was significant or approached significance for carcass weight, cutability, longissimus area, fat thickness and KHP fat.

Least-squares means for carcass weight traits, fat thickness and longissimus area are presented by crossbred cow group in Table II. Compared to the average carcass weight of calves from HA and AH cows (319 kg), calves from S and B cross cows, respectively, produced 30 kg (9 %) and 20 kg (6 %) heavier carcasses. Calves from JA and JH cows, respectively, produced 20 kg (6 %) and 13 kg (4 %) lighter carcasses than calves from HA and AH cows. Carcass weight per d of age was greater for calves from AH cows (705 g/d) than for calves from HA (685 g/d) or J cross cows (averaged 679 g/d). Calves from S and B cross cows attained similar carcass weights per d of age (averaged 738 g/d), and exceeded the average of calves from HA and AH cows by 6 %. Young et al. (1978) reported the same ranking among steers from HA reciprocal, S and J cross cows mated to Hereford, Angus, Brahman, Devon and Holstein bulls for carcass weight adjusted to a constant age, but differences were not significant (p>.05). USMARC Progress Report No. 6 (1978) reported 23 kg (7 %) heavier carcass weights for steers from B cross cows than for calves from HA reciprocal cross cows (marbling scores were similar among calves from B cross and HA reciprocal cross cows). In the latter study, steers were sired by Hereford, Angus, Brangus and Santa Gertrudis bulls.

External carcass fat thickness was greatest for calves from HA and AH cows (averaged 1.51 cm) and least for calves from BH and JH cows (averaged 1.17 cm). The average fat thickness for calves from S cross, BA and JA cows was 1.29 cm. Young et al. (1978) reported less fat thickness for steers from S cross cows than for steers from HA reciprocal or J cross cows (HA reciprocal and J crosses were similar) when adjusted to a constant age and when adjusted to a constant carcass weight. USMARC Progress Report No. 6 (1978) reported greater .36 cm greater fat thickness for calves from HA cross cows than for calves from B reciprocal cross cows.

Compared to the average for calves from HA and AH cows (81.8 cm^2), longissimus area was 4.8 cm^2 (6 %) larger for calves from S cross cows and 3.7 cm^2 (5 %) smaller for calves from JA cows. Similar to calves from HA and AH cows in longissimus area were calves from B cross (84.3 cm^2) and JH (80.1 cm^2) cows. Young et al. (1978) reported larger longissimus areas for steers from S cross cows than for steers from HA reciprocal and J cross cows when adjusted to a constant age (71.6 vs an average of 66.5 cm^2) and when adjusted to a constant carcass weight (71.3 vs an average 67.6 cm^2). In both analyses, means for HA reciprocal and J cross groups were similar. USMARC Progress Report No. 6 (1978) reported larger ribeye area for calves from B cross steers than for calves from HA reciprocal cross steers (76.8 vs 66.5 cm^2).

Least squares means for estimated KHP fat, dressing percentage, cutability, marbling and quality grade are presented in Table III. Calves from J cross cows had slightly more estimated internal (KHP) fat than did calves from HA and SH cows (3.31 vs 3.08 %). Carcasses of other groups had an average of 3.19 % KHP fat. Young et al. (1978) reported lower estimated percentage of KHP fat for steers from S cross cows than for steers from HA reciprocal and J cross cows when adjusted to a constant age and when adjusted to a constant carcass weight. USMARC Progress Report No. 6 (1978) reported similar percentages of estimated KHP fat for calves from HA reciprocal and B cross cows.

Dressing percentage was greater for calves from AH, SH and BH cows (64.3 %) than for calves from HA and J cross cows (averaged 63.4 %). Calves from SA and BA cows had intermediate dressing percentages (averaged 64.0 %). USMARC Progress Report No. 6 (1978) reported dressing percentages of 61.8 and 62.3 for calves from HA reciprocal and B cross cows, respectively.

Estimated cutability was significantly greater for calves from BH, S and J crosses (averaged 49.8 %) than for calves from HA cows (49.2 %). Cutability was significantly greater for calves from JH cows than for calves from AH cows (49.9 versus 49.4 %). There were no significant differences in cutability among S, B and J cross groups. Young et al. (1978) reported a higher percentage of retail product for steers from S cross cows than for steers from HA reciprocal and J cross cows when adjusted to a constant age and when adjusted to a constant carcass weight. In both analyses, means for HA reciprocal and J cross groups were similar. USMARC Progress Report No. 6 (1978) reported higher estimated cutability for calves from B cross cows than for calves from HA reciprocal cross cows.

On the average, calves were slaughtered at the intended low choice carcass grade with little variation among crossbred cow groups. Crossbred cow group least squares means ranged from 5.0 to 5.2 for marbling score (averaged 5.1) and ranged from 9.8 to 10.1 for carcass quality grade (averaged 10.0). In the study reported by Young et al.

(1978), differences among steers from HA reciprocal, S and J crossbred cow groups were not significant for these traits. In the study reported by USMARC Progress Report No. 6 (1978), crossbred cow group means were similar for steers from HA reciprocal and B cross cows for marbling score and quality grade .

Presented in Table IV are measures of production of carcass weight per cow exposed to breeding and estimated boneless, closely trimmed retail cuts per cow exposed to breeding. Characterization of breed types by these measures takes into consideration cow reproduction, calf survival and calf carcass growth (the latter measure also takes cutability into account). Production of carcass weight per cow exposed was 8 kg/cow (3.4 %) greater for the HA group than for the AH group. Compared to the average of the HA and AH groups, production of carcass weight per cow exposed averaged 6 kg/cow (2.6 %) less for the BH group, similar for SH and JH groups and 13 kg/cow (5.4 %) greater for the SA, BA and JA groups. Excluding the HA and AH groups, A crosses produced 5.7 % more carcass weight per cow exposed than H crosses, largely reflecting the advanatage in reproductive performance of the A crosses over the H crosses (Frahm and Marshall, 1985). Similar rankings were attained for production of retail cuts per cow exposed to breeding. The HA group produced 3 kg (2.6 %) more retail cuts per cow exposed than the AH group. Compared to the average of HA and AH (115.5 kg/cow), production of retail cuts per cow exposed averaged 3 kg/cow (2.6 %) for SH and JH groups and 7.5 kg/cow (6.5 %) greater for SA, BA and JA groups. Excluding the HA and AH groups, A crosses produced 5.1 % more retail cuts per cow exposed than H crosses.

Conclusions. While maternal traits are generally emphasized in studies evaluating dam breed types, carcass merit of calves is also an important consideration, especially in a terminal breeding program. With the exception of carcass weight, magnitudes of differences among crossbred cow groups in this study were relatively small for the traits evaluated. In general, both steer and heifer carcasses of all breed groups were quite acceptable and desirable from a consumer standpoint.

TABLE I

PROBABILITIES OF ATTAINING GREATER F-VALUES FROM FULL MODEL ANALYSES OF VARIANCE

Source	df[a]	Carcass wt	Carcass wt/day of age	Fat thickness	Longissimus area	Estimated KHP fat	Dressing percentage	Cutability	Marbling score	Carcass grade
Calf sire breed (B)	3	.01	.01	.01	.01	.01	.01	.01	.36	.33
Year (Y)/B	10	.01	.01	.01	.01	.01	.01	.01	.01	.01
Sire/Y/B	84	.01	.01	.01	.01	.01	.21	.01	.01	.01
Crossbred cow group (C)	7	.01	.01	.01	.01	.01	.63	.12	.71	.54
Cow age (A)	2	.18	.12	.98	.22	.81	.53	.84	.02	.01
Calf sex (S)	1	.01	.01	.20	.01	.08	.13	.03	.63	.30
B x C	21	.47	.63	.02	.07	.12	.39	.64	.01	.02
B x S	3	.22	.06	.54	.41	.58	.06	.37	.83	.75
C x A	14	.49	.96	.20	.03	.26	.79	.01	.24	.13
C x S	7	.22	.06	.13	.51	.06	.35	.34	.05	.15
A x S	2	.02	.01	.17	.13	.11	.28	.02	.02	.08
Initial age	1	.01	.01	1.00	.01	1.00	.15	1.00	.10	.04
Marbling score	(1)	.01	.48	.01	.07	.01	.13	.01		
Remainder	1350(1349)									

[a] Number in parentheses represents df for models in which marbling score was included as a covariate.

TABLE II

LEAST SQUARES MEANS FOR CARCASS WEIGHT TRAITS, FAT THICKNESS AND LONGISSIMUS AREA

Crossbred cow group[a]	No. carcasses	Carcass wt		Carcass wt/ day of age		Fat thickness		Longissimus area	
		kg	% HA,AH	g/d	% HA,AH	cm	% HA,AH	cm^2	% HA,AH
HA	175	318^{e}	99.7	685^{e}	98.6	1.55^{c}	102.6	81.6^{f}	99.8
AH	168	320^{e}	100.3	705^{d}	101.4	1.47^{cd}	97.4	82.0^{ef}	100.2
SA	208	348^{c}	109.1	741^{c}	106.6	1.28^{ef}	84.8	87.1^{c}	106.5
SH	159	349^{c}	109.4	738^{c}	106.2	1.25^{efg}	82.8	86.0^{cd}	105.1
BA	173	338^{d}	106.0	735^{c}	105.8	1.36^{de}	90.1	83.2^{def}	101.7
BH	158	339^{d}	106.3	737^{c}	106.0	1.20^{fg}	79.5	85.3^{cde}	104.3
JA	236	299^{g}	93.7	674^{e}	97.0	1.28^{ef}	84.8	78.1^{g}	95.5
JH	229	306^{f}	95.9	683^{e}	98.3	1.14^{g}	75.5	80.1^{fg}	97.9
Overall	1506	327		712		1.32		82.9	
Avg S.E. of mean		5.88		19.8		.071		1.66	
Avg S.E. of diff.[b]		2.85		7.34		.061		1.48	

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[b] Average standard of difference between pairs of means.

[cdefg] Mean in the same column not sharing a common superscript differ ($P<.05$).

TABLE III

LEAST SQUARES MEANS FOR KHP FAT, DRESSING PERCENTAGE, CUTABILITY, MARBLING AND QUALITY GRADE

Crossbred cow group^{a}	No. carcasses	Estimated KHP fat, %	Dressing percentage, %	Cutability, %	Marbling score^{b}	Quality grade^{c}
HA	175	3.10^{gh}	63.7^{fgh}	49.2^{g}	5.1	10.0
AH	168	3.18^{fgh}	64.3^{e}	49.4^{fg}	5.1	10.1
SA	208	3.19^{efgh}	64.0^{ef}	49.8^{ef}	5.1	9.9
SH	159	3.06^{h}	64.3^{e}	49.8^{ef}	5.0	9.8
BA	173	3.22^{efg}	63.9^{efg}	49.5^{efg}	5.0	10.0
BH	158	3.18^{efgh}	64.3^{e}	49.7^{ef}	5.2	10.1
JA	236	3.33^{e}	63.4^{gh}	49.8^{ef}	5.0	9.9
JH	229	3.28^{ef}	63.2^{h}	49.9^{e}	5.0	9.9
Overall	1506	3.19	63.9	49.6	5.1	10.0
Avg S.E. of mean		.094	.268	.286	.14	.19
Avg S.E. of diff.^{d}		.067	.274	.205		

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[b] 5=small, 6=modest amount of marbling.

[c] 9=good +, 10=choice -, 11=choice avg.

[d] Average standard error of difference between pairs of means.

[efgh] Means in the same column not sharing a common superscript differ ($P<.05$).

TABLE IV

PRODUCTION OF CARCASS WEIGHT AND ESTIMATED RETAIL CUTS PER COW EXPOSED TO BREEDING

Crossbred cow group[a]	Carcass wt per cow exposed[b]		Retail lean cuts per cow exposed[b]	
	Kg/cow	% HA,AH	Kg/cow	% HA,AH
HA	239	101.7	117	101.3
AH	231	98.3	114	98.7
SA	248	105.5	123	106.5
SH	236	100.4	118	102.2
BA	250	106.4	124	107.4
BH	229	97.4	114	98.7
JA	245	104.3	122	105.6
JH	238	101.3	119	103.0
Overall	240		119	

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[b] Based on number of cows exposed to breeding.

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CHAPTER VI

PERFORMANCE COMPARISONS AMONG VARIOUS TWO-BREED CROSS COW GROUPS. IV. ECONOMIC EVALUATION OF CALF PRODUCTION

Summary

A systems approach was used to evaluate economic efficiency of calf production of various two-breed cross cow groups (Hereford X Angus reciprocal crosses, HAx; Simmental X Angus, SA; Simmental X Hereford, SH; Brown Swiss X Angus, BA; Brown Swiss X Hereford, BH; Jersey X Angus, JA and Jersey X Hereford, JH) in a terminal crossbreeding system. Crossbred cow group differences in reproductive performance, feed requirements, calf growth rate, calf survival, calf carcass merit and cow salvage weight were considered in the system. Land area for the breeding herd was held constant and supplemental feed was purchased as needed to meet requirements. Feedlot nutrients were purchased as needed to allow calves to attain a low choice carcass grade. The number of cow-calf units per herd for the specified land area was greatest for J crosses and lowest for S crosses. Herds using SH and BH cows required the most replacement heifers to maintain constant herd size (herds using J crosses required the fewest), but gross returns from the sale of cull cows were also greater for SH and BH groups. Gross returns from the sale of slaughter calves was greatest for herds using BA, J cross and HAx cows and lowest for herds using S cross cows. Total costs were greatest for herds using SH cows and lowest for herds using JA and SA cows. The relative advantages and disadvantages of the various crossbred cow groups tended to largely offset one another, resulting in small differences among groups in relative profitability of slaughter calf production. Gross margin per herd, used to evaluate relative profitability among crossbred cow groups, was greatest for the BA group. Herds using J cross, HAx, BH and SH cows produced slightly lower gross margins, followed closely by herds using SA cows. However, rankings for gross margin changed when the cost of replacement heifers was varied. Rankings changed only slightly when the cost of feedlot TDN was varied. In a separate analysis in which birth rate was held constant across crossbred cow groups, gross margins for slaughter calf production were highest for herds using SH cows, followed in order by herds using B cross, HAx, SA and J cross cows.

(Key Words: Beef cattle, Crossbreeding, Economic Efficiency).

Introduction

This study is a portion of a comprehensive research project evaluating lifetime productivity of various two-breed cross cow groups (Hereford X Angus reciprocal crosses, HAx; Simmental X Angus, SA; Simmental X Hereford, SH; Brown Swiss X Angus, BA; Brown Swiss X Hereford, BH; Jersey X Angus, JA and Jersey X Hereford, JH) when mated to bulls of a third breed. To accurately determine the net worth of a breed type to the entire beef industry, it is necessary to evaluate breed types for a variety of important production traits, taking into consideration all production segments (i. e., cow-calf, stocker-feedlot and slaughter-packing). Important differences among the two-breed cross dam groups have been reported for milk production (Chenette and Frahm, 1981), cow nutrient requirements (Marshall et al., 1984), cow productivity and calf performance to weaning (Belcher and Frahm, 1979; Frahm and Marshall, 1985), calf feedlot performance (Marshall and Frahm, 1985) and calf carcass characteristics (Marshall et al., 1985). Crossbred cow group rankings were quite variable across the spectrum of traits evaluated, suggesting relative advantages and disadvantages of each crossbred type. The objective of this study was to evaluate economic differences among these two-breed cross cow groups, utilizing biological differences from experimental results and economic considerations under specified management situations.

Materials and Methods

A deterministic model was developed to simulate a terminal crossbreeding, cow-calf-feedlot beef production system. A spring calving season was assumed and calves were weaned in the fall at 205 d of age. Replacement heifers were purchased in the spring at 1 yr of age and exposed to bulls during the summer breeding season. Pregnant heifers entered the cow herd at weaning time.

Crossbred cow groups were compared under two alternative cow culling systems: CULL1, nonpregnant cows and heifers were culled at weaning time in the fall; CULL2, nonpregnant cows and heifers were culled in the fall and cows and heifers without a live calf in the spring were culled at the end of the calving season. In addition, 1 % management culls (sold at weaning) and 2 % annual cow death loss were assumed for each crossbred cow group.

Land size for the breeding herd was fixed at 405 ha. Within each culling system, the given land area was assumed sufficient to provide pasture for 100 HAx cow-calf units (cows of approximately 450 kg mature size), including replacements, under typical north central Oklahoma range conditions. Supplementary cottonseed meal and bermudagrass hay were purchased to allow cows to meet protein and energy requirements. Nutrients required for the feedlot segment of production were purchased as needed. Calves entered the feedlot immediately after weaning and were fed a corn-milo finishing ration (Marshall and Frahm, 1985) until attaining a low choice carcass grade.

The carrying capacity (or equivently, herd size) for a given crossbred dam group was a function of the land requirements of the breeding herd, reproductive performance and culling alternative. A sufficient number of replacement heifers were purchased to maintain a constant herd size from year to year, even though herd size varied during the year. In addition, the proportion of yearling replacement heifers, first calf cows and older cows remained constant over years. Crossbred cow group comparisons were made over one production cycle under the assumption that the base cow herd had already reached equilibrium with respect to age composition. For greater precision in calculations, fractions of animals were allowed to exist. Hence, it is desirable to think in terms of numbers of animals per herd, where herd is the total conglomeration of cattle produced under the specified land area restriction.

The bioeconomic model attempted to account for crossbred dam group differences for reproductive performance, nutrient requirements, calf growth rate, calf survival, carcass composition and cow salvage weights. The majority of biological data used in this study were obtained from the previous papers in this series (Frahm and Marshall, Marshall and Frahm, Marshall et al., 1985), reporting performance of 3- through 9-yr-old cows and their calves for the cow-calf, feedlot and carcass segments of production. The number of calves evaluated ranged from 1721 for birth traits to 1506 for carcass traits. Productivity of 434 2-yr-old cows and preweaning performance of their calves were reported by Belcher and Frahm (1979). Crossbred cows were mated to Red Poll and Shorthorn bulls as 2-yr-olds and to Charolais, Brahman, Limousin and Gelbvieh bulls at subsequent ages. Feedlot and carcass data for calves from 2-yr-old cows were reported by Chenette et al. (1977). All three-breed calf performance data used in this analysis were the average of steer and heifer performance. Nutrient requirements of yearling replacement heifers and 2-yr-old cows were calculated from NRC (1974), based on weights and first lactation milk yields reported by Belcher and Frahm (1979). Nutrient requirements of older cows were based on individual feed intake data of drylotted cows reported by Marshall et al. (1984).

It is uncertain if existing environmental conditions allowed cows to reproduce at rates typical of the respective crossbred cow groups. Under the assumption that the levels of pasture and supplement provided were appropriate for cow size and lactation level, and should provide adequate nutrition for all crossbred cow groups to reproduce at the same level, an additional analysis was done in which a constant birth rate of 90 % was assumed for all crossbred groups.

Since land area utilized by the breeding herd was the same for each crossbred dam group (within a given culling system), pasture costs were not considered. In addition, the cost of establishing existing herds was assumed to be the same for all crossbred cow groups and thus was ignored. Relative profitability of crossbred cow groups was estimated by subtracting all costs for a given herd, except fixed herd costs, from total gross returns. Thus, crossbred cow groups were compared on gross margin per herd. Differences among crossbred cow groups in gross margin per herd would be eqivalent to differences in net income per herd. Gross margin was calculated for selling calves at weaning and for selling calves at slaughter. Three different product end points were considered for slaughter calf production: live weight, carcass weight and boneless, closely trimmed retail cuts.

Economic coefficients assumed for cattle and feedstuffs were based on a 6 yr (1977-1982) average of Oklahoma prices. The cost of cottonseed meal and bermudagrass hay were set at $.2692 and $.0441 per kg dry matter, respectively. The cost of nutrients for feedlot calves was set at $.1742/kg TDN. To test the sensitivity of crossbred dam group rankings to the relative cost of nutrients for the breeding herd versus the feedlot, the cost of feedlot TDN was later varied.

Calf prices were averaged over steers and heifers. Prices assumed for weaned weight, live slaughter weight, carcass weight and retail cuts were $1.4387/kg, $1.3340/kg, $2.0876/kg and $4.2089/kg, respectively. Yearling replacement heifers were purchased for $1.4310/kg, calculated as a $.10/kg premium over feeder heifer prices (variations in heifer costs were later examined). Nonpregnant heifers sold for $1.3150/kg (the price of slaughter heifers) and cull cows sold for $.8610/kg.

A breeding cost of $15.60 was charged per cow and heifer exposed to breeding. This figure assumes that a bull was purchased at $1200, maintained at a cost of $300/yr, serviced 30 females per yr, and was sold at $700 after 3 yr service.

Smith (1976) assumed a $4 labor charge per difficult birth, plus $16 for increased replacement rate due to calving difficulty (other costs were later examined). Elliot et al. (1981) assumed a cost of $100 per Caesarian birth for veterinarian services and drugs administered. A direct cost of $20 per difficult birth was assumed in this study. This figure was obtained by charging $4 per non-Caesarian difficult birth and $100 per Caesarian birth and assumes that 17% of all difficult births required Caesarian sections (unpublished data). Indirect effects of calving difficutly on subsequent calf mortality and fertility were assumed to be reflected in weaning rates. Hence, most of the effects of calving difficulty on replacement rate (Laster et al., 1973; Smith, 1976) were assumed to be accounted for, although effects on subsequent cow mortality were ignored.

Other operating costs were based on enterprise budgets supplied by the Oklahoma Cooperative Extension Service (1980). Per head costs of $50 for cows remaining in the herd for the full annual production cycle, $30 for cows culled in the spring and $28 per yearling heifer were charged to account for veterinary supplies and services, utilities, labor, machinery and miscellaneous expenses of the breeding herd. Non-feed expenses for the feedlot segment included a charge for veterinary supplies and services of \$5.50/head, a marketing cost of \$13.25/head and a lot charge of \$.05/head/day fed.

Cumulative capital expenditures and returns were updated monthly and interest expense or interest income was computed at monthly intervals, assuming an annual interest rate of 13 %. Interest was not charged on fixed herd costs, since the value of these were assumed to be the same for all crossbred cow groups.

Results and Discussion

All tabular results are presented by crossbred cow group and culling system. Comparisons among crossbred cow groups were made within culling system. Comparisons of culling systems were not generally made since the intent of including alternative culling systems was not to aid in making management decisions, but rather to determine whether or not crossbred cow group rankings differed over different culling systems. Except when noted otherwise, rankings among crossbred cow groups were consistent over culling alternatives.

Herd inventory for various classes of cattle are presented in table I. These results are quite useful in evaluating relationships between nutrient requirements, reproductive performance, culling system and replacement rate. The number of cows calving was fixed at 100 for the HAx group. Since land area available for the breeding herd were the same for each crossbred dam group, fewer animals were maintained for those groups with higher land requirements. Under culling system CULL1, for example, compared to the HAx group, the number of cows calving was greater for the J crosses by an average of 7 cows per herd, while the B and S groups averaged 9 and 13 cows less, respectively. Lower reproductive rates required that a higher proportion of nutrients be used for development of replacement heifers, leaving less land available for pregnant and lactating cows. The number of heifers purchased and the numbers of heifers and cows sold were greater under culling system CULL2 than under system CULL1, since most of the cows culled in the spring under system CULL2 would have become pregnant and retained in the herd under system CULL1.

Considerably more yearling heifers were purchased for herds using SH and BH cows than for herds using other crossbred cow groups, influenced partly by the poor rebreeding performance of these cows under extensive range conditions (Frahm and Marshall, 1985), but influenced also by failure of heifers to become pregnant during the limited breeding season (Belcher and Frahm, 1979). The latter factor affected the SH group in particular. For example, the number of yearling heifers needed for the SH group was greater than for the BH group, even though the number of cows culled (sold) was similar for those 2 groups. Fewest cows and nonpregnant heifers were sold and fewest replacements needed in systems using J cross cows.

Number of calves weaned and slaughtered depended primarily on the number of cows calving, but also on calf survival. Under culling system CULL1 for example, HAx cows produced 7.9 more calves than BA cows at birth, but the difference was reduced to 2.7 calves at weaning and 2.5 calves at slaughter. Compared to the SA group, there were 4.0 more BA calves at birth, but 8.2 and 8.6 more calves at weaning and slaughter, respectively. The consequences of these differences are discussed later in the paper. Even though the numbers of cows calving in herds using HAx cows were the same under both culling systems, the cow age distribution varied, resulting in slightly more calves weaned and slaughtered under culling system CULL1 than under CULL2.

Non-feed expenses and gross returns per herd when calves are sold at weaning are presented in Table II. Variation among crossbred cow groups in dollars spent purchasing yearling heifers contributed the most of any source to variation in total expenses. The expense of purchasing yearling heifers was greatest for the SH and BH groups and least for herds using J cross cows. Non-feed operating expenses for the breeding herd were generally higher for those groups with higher numbers of cows and heifers, but the magnitudes of differences were relatively small. Jersey cross cows produced the most milk, especially in proportion to body size, and thus supplement requirements per cow were similar to other groups even though the J crosses were smaller. Total herd supplement costs were greatest for J crosses and least for SH cows. Replacement heifers were purchased in the spring when pasture conditions required little supplementation. Thus herds using SH cows had relatively low supplement costs, since this group had a relatively high proportion of heifers..

The proportion of total gross returns consisting of income from the sale of cull cows and nonpregnant heifers was greater under culling system CULL2 than under CULL1. Both reproductive performance and salvage weight contributed to the amount of returns from these sources. Returns from the sale of cull cows was greatest for SH and BH cows, intermediate for BA, SA and HAx cows and lowest for J cross cows. However, rankings of S and B crosses differed over culling systems. Under system CULL1, cull cow returns were $789/herd greater for BA than for SA cows, and $137/herd greater for BH than for SH cows. However, under system CULL2, cull cow returns were $227/herd greater for SA than for BA cows, and $302/herd greater for SH than for BH cows. These changes in rank occurred because a higher proportion of pregnant B cross cows produced a live calf at birth as compared with S cross cows (Belcher and Frahm, 1979; Frahm and Marshall, 1985). Rankings for gross returns from the sale of nonpregnant heifers were the same as rankings for number of nonpregnant heifers sold.

If calves were sold at weaning and calves from all crossbred cow groups were sold at the same price per unit weight, returns were greatest for calves from J cross cows, followed in order by calves from B cross, HAx and S cross cows. Total gross returns per herd were greatest for herds using SH and B cross cows, as a result of the large numbers of culled cows.

Expenses and gross returns per herd when calves are sold at slaughter are presented in Table III. Even though feed costs comprised a large proportion of total non-fixed herd expenses, differences in feed costs among crossbred cow groups were relatively small, as breed groups with higher per calf feed requirements (i. e., S and B crosses, Chenette et al., 1977; Marshall and Frahm, 1985) had fewer calves in the feedlot, with the 2 factors largely offsetting each other. The largest difference in feed costs under culling system CULL1 was the $3250 greater feed costs for calves from JH cows than for calves from SH cows. Although the lot charge depended on the number of calves fed and on length of the feeding period, crossbred cow group differences in non-feed operating costs in the feedlot primarily reflected differences in number of calves fed. Total non-fixed herd expenses for slaughter calf production were lowest for SA and JA groups and greatest for herds using SH cows.

Gross returns from the sale of slaughter calves was estimated at three product endpoints: live weight, carcass weight and retail cuts. The use of carcass weight favored groups with relatively high dressing percentage and the use of retail cuts favored groups with high dressing percentage and high cutability. However, crossbred cow group rankings were quite similar for each product end point and culling system combination. Gross returns from the sale of slaughter calves was greatest for herds using J cross cows, followed by herds using BA and HAx cows. The relatively heavy weights of calves from S cross cows (Marshall and Frahm, 1985; Marshall et al., 1985) did not completely compensate for their smaller numbers of calves per herd, resulting in lower gross returns per herd. Herd total gross returns, including returns from the sale of slaughter calves and culled cows, were greatest for herds using SH and BA cows.

Gross margin for selling calves at weaning or slaughter are presented in Table IV. For production systems in which calves were sold at weaning, gross margin per herd was greatest for J cross cows, followed in order by B cross, HAx and S cross cows. Gross margins for slaughter calf production was greatest for the BA group at all 3 product end points. Herds using J cross, HAx, BH and SH cows produced slightly lower gross margins, followed closely by herds using SA cows. Crossbred dam group rankings for gross margin for slaughter calf production were similar across product end point and culling system, with the only rank changes being between groups for which pair-wise diffrences were very small.

Rankings for J crosses reflect their advantage in reproductive performance and moderate preweaning growth rate (Belcher and Frahm, 1979; Frahm and Marshall, 1985), but relatively poor postweaning calf feedlot performance (Marshall and Frahm, 1985). Brown Swiss crosses had moderate reproductive performance, produced the heaviest calves at weaning and had relatively good postweaning performance. Hereford X Angus reciprocal cross cows had moderate reproductive performance, produced the lightest calves at weaning, but their calves were the most efficient in the feedlot. The S crosses ranked last in gross margin, despite relatively high weaning weights and good feedlot performance. The low ranking of the SH group was largely because of poor reproductive performance under the extensive range conditions. The relatively high energy requirements for SA cows (Marshall et al., 1984) contributed to their low ranking. Another important factor in the ranking of S crosses, especially for the SH group, was preweaning calf losses. As mentioned previously, the number of calves alive at 24 hr after birth and the number weaned, in proportion to the number of cows calving, was lowest for S crosses. Females which went into the pregnant herd in the fall, but failed to wean a calf, had to be maintained for much or all of the year (depending on when the calf died and the culling system assumed). This was less desirable than a cow failing to become pregnant. The relatively high incidence of calving difficulty among S cross cows (Belcher and Frahm, 1979; Frahm and Marshall, 1985) may have contributed to calf mortality.

Differences among crossbred cow groups for gross margin when calves were sold at slaughter were quite small, reflecting the trade-offs among the relative merits and disadvantages of the various crossbred groups. The relative economic advantage of BA and J crosses over HAx, S cross and BH cows was considerably less when calves were sold at slaughter than when calves were sold at weaning. The better feedlot performance for calves from HAx, S cross and BH cows indicates that feedlot operators should pay less per unit weight for calves from J cross and BA cows at weaning. It is interesting to note that crossbred cow groups which produced the highest average milk yields (i. e., BA and J crosses) also produced calves which were least efficient (in terms of feed conversion) in the feedlot. Unfortunately, had a reasonable land charge for the breeding herd been included in expenses, all crossbred dam groups would likely have been operating at a loss. This would seem consistent with the economic situation many cattlemen have experienced in recent years.

In experimental data collected previously for this project, A cross cows have consistently had better reproductive performance than H crosses (Belcher and Frahm, 1979; Frahm and Marshall, 1985). On the other hand, H crosses have consistently had superior feed conversion, among drylotted cows producing weaned calves (Marshall et al., 1984) and among feedlot calves (Marshall and Frahm, 1985). Results from these economic analyses indicate that the relative advantages and disadvantages of A and H crosses were apparently offsetting when all segments of production were considered, resulting in similar gross margins for A and H crosses.

The extent to which environmental conditions allowed cows to reproduce at rates typical for these crosssbred cow groups is uncertain. However, the extensive range conditions apparently failed to provide sufficient energy for desirable reproductive performance for the larger S and B cross cows, in particular. Presented in Table V are gross margins for herds producing weaned calves or slaughter calves, when a constant birth rate of 90% was assumed for all crossbred cow groups. If calves were sold at weaning, B cross cows produced the highest gross margins, followed in order by J cross, SH, HAx and SA cows. If calves were sold at slaughter, herds using SH cows produced the highest gross margins, followed closely by B cross cows. Herds using HAx cows produced slightly lower gross margins, followed closely by herds using SA and J cross cows. Simmental X Hereford and BH cows had the lowest reproductive rates among the crossbred cow groups evaluated, and thus their relative profitability improved the most by assuming a constant birth rate. These calculations (Table V) ignore potential increased feed costs associated with increased reproductive performance.

It has been assumed in this analysis that economic coefficients are known with certainty. If the assumed coefficients were to change, the results of this analysis would likely change as well, unless all economic coefficients changed proportionally. One concern in this study was that of the cost of replacement heifers. It was assumed that the cost of producing yearling replacement heifers from these two-breed crosses was the same per unit weight for all crosses. In a fully integrated system, the efficiency of purebred herds producing the crossbred replacements would be considered. Since the cost of producing replacement heifers was not known, the sensitivity of crossbred dam group ranking to cost of replacement heifers was examined by calculating gross margin at alternative replacement costs.

Figure 1 shows gross margins for calves sold at weaning, under culling system CULL1, at low, moderate and high costs of purchasing replacement heifers. The moderate cost represents the cost previously assumed, while low- and high-cost heifers, respectively, were purchased at $50/head below and $50/head above the cost of moderate-cost heifers. Results indicate that crossbred dam group rankings were fairly stable over the range of heifer costs evaluated, although magnitudes of differences in gross margins increased as heifers costs increased. The SH group was most affected, because of the large number of yearling heifers purchased for this group. For example, the gross margin of the HAx cows was $608 less than that for SH cows at the low heifer cost, but $1215 greater at the high heifer cost.

Figure 2 shows gross margins for slaughter calf production under culling system CULL1 at high, moderate and low heifer costs, assuming retail cuts as the product endpoint. The SH group ranked second in gross margin at low heifer costs, but ranked next to last at high heifer costs. However, the magnitudes of differences were relatively small. At low and moderate heifer costs, the largest difference between pairs of crossbred dam groups was between BA and SA (difference was $1945 and $1897 for low and moderate, respectively). At high heifer costs, the largest difference was between JA and SA groups ($2011).

Figure 3 shows gross margins for production of retail cuts under culling system CULL1 when the cost of feedlot TDN was set at levels 25% below (low) and 25% above (high) the originally assumed price (moderate). Crossbred dam group rankings were quite stable over the range of feedlot TDN costs evaluated, with the only changes in rank occurring between groups for which gross margins were similar. Similarly, Smith reported that varying the grain to forage price ratio had little effect on interpretion of economic comparisons among terminal sire breeds. However, in an evaluation of the effects of mature size on efficiency, Notter et al. (1979) found that small cow types were more efficient than larger types when the feedlot to cow herd TDN cost ratio was high. Notter et al. (1979) reasoned that if calves were weaned at a constant age, then the proportion of a calf's growth occurring postweaning increases as mature size increases. Long et al. (1975) found that small cow types were more profitable under pasture management where cow herd feed costs were relatively cheap, but that large cow types were more profitable under drylot management where cow herd feed were more expensive. The latter two studies involved evaluation of size types rather than specific breed types. Breed type and mature size were confounded in the present study.

Conclusions. Differences among crossbred cow groups for various production traits resulted in considerable variation in herd size, replacement rate and herd composition. However, the relative advantages and disadvantages of the various crossbred cow groups tended to offset one another to varying degrees, resulting in small to moderate differences in overall gross margin. Gross margins for slaughter calf production was greatest for the BA group, followed closely by herds using J cross, HAx, BH and SH cows. Herds using SA cows were slightly less profitable. Results are dependent on sampling of the breed types used, the environmental conditions under which the experimental data were collected and on the assumptions used in the analysis. Any deviations from these may have given different results. For example, the extensive range conditions apparently did not provide sufficient energy for desirable reproductive rates for the larger S and B cross cows. However, it is uncertain whether or not the potential increase in reproductive efficiency would have offset the increased feed costs. Hopefully, data from other studies involving these crossbred cow groups under different sets of environmental conditions may provide additional information to help determine which crossbred types perform best under given environmental conditions.

TABLE I

HERD INVENTORY FOR VARIOUS CLASSES OF CATTLE

Crossbred	No. cows calving		No. yearling heifers purchased		No. cows sold		No. nonpregnant heifers sold		No. calves weaned		No. calves slaughtered	
cow group[a]	CULL1[b]	CULL2[b]	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2
HAx	100.0	100.0	17.1	21.5	12.8	17.1	2.3	2.9	88.9	88.7	87.7	87.4
SA	88.1	87.4	17.1	22.9	12.1	17.2	3.2	4.3	78.0	77.3	76.6	75.9
SH	83.9	82.5	34.0	40.2	18.0	20.8	14.4	17.0	76.5	75.2	76.2	74.9
BA	92.1	92.1	18.0	20.1	15.0	17.3	1.2	1.3	86.2	86.1	85.2	85.0
BH	87.8	87.3	26.6	29.4	19.0	20.6	5.9	6.5	81.9	81.4	79.4	78.9
JA	105.6	104.6	7.9	11.8	5.0	8.2	.8	1.2	97.3	96.6	96.0	95.3
JH	107.5	106.1	11.1	17.0	8.4	13.6	.6	.9	97.7	96.6	95.7	94.7

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[b] Culling systems: CULL1, open cows were culled at weaning in the fall; CULL2, open cows were culled in the fall and cows without a live calf at the end of the calving season were culled in the spring.

TABLE II

NON-FIXED EXPENSES AND GROSS RETURNS PER HERD WHEN CALVES ARE SOLD AT WEANING

Crossbred cow group[a]	Expenses ($/herd)								Gross returns, $/herd							
	Yearling heifer purchase		Non-feed operating costs		Supplement		Total		Nonpregnant heifers		Cull cows		Weaned calves		Total	
	CULL1[b]	CULL2[b]	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2
HAx	5444	6834	8926	9110	7963	7807	22,333	23,751	809	1016	4509	5843	26,583	26,290	31,902	33,149
SA	6125	8180	8252	8421	7938	7669	22,314	24,270	1265	1690	4622	6369	25,708	25,232	31,596	33,291
SH	11,250	13,289	8924	9159	7064	6811	27,237	29,259	5250	6202	6711	7669	24,541	23,887	36,502	37,758
BA	6209	6920	8406	8569	8036	7936	22,651	23,425	433	483	5411	6142	28,860	28,730	34,705	35,355
BH	8651	9554	8511	8687	7335	7207	24,497	25,448	2103	2323	6848	7367	27,087	26,758	36,039	36,448
JA	2401	3569	8673	8888	9093	8899	20,167	21,356	269	399	1577	2571	31,411	31,007	33,256	33,977
JH	3362	5170	9115	9267	8983	8683	21,460	23,120	187	287	2653	4264	31,480	30,845	34,320	35,396

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[b] Culling systems: CULL1, open cows were culled at weaning in the fall; CULL2, open cows were culled in the fall and cows without a live calf at the end of the calving season were culled in the spring.

TABLE III

EXPENSES AND GROSS RETURNS PER HERD WHEN CALVES ARE SOLD AT SLAUGHTER

	Additional expenses, $/herd[c]				Total herd expenses $/herd[d]		Gross returns at 3 end points, $/herd						Total returns at 3 end points, $/herd[e]					
	FEEDLOT TDN		Feedlot operating costs				Live wt		Carcass wt		Retail cuts		Live wt		Carcass wt		Retail cuts	
Crossbred cow group[a]	CULL1[b]	CULL2[b]	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2
HAx	22,588	22,291	3744	3647	48,665	49,689	56,420	55,703	56,061	55,275	55,440	54,586	61,739	62,561	61,379	62,133	60,758	61,445
SA	21,600	21,033	3371	3207	47,285	48,510	53,346	52,142	53,088	51,776	53,031	51,623	59,234	60,201	58,976	59,835	58,919	59,682
SH	20,639	19,962	3136	2966	51,012	52,187	52,137	50,572	51,727	50,105	51,420	49,698	64,098	64,443	63,688	63,976	63,381	63,569
BA	23,386	23,219	3582	3526	49,619	50,171	57,894	57,532	57,362	56,966	56,919	56,487	63,738	64,157	63,207	63,592	62,764	63,112
BH	21,453	21,139	3280	3194	49,230	49,781	53,089	52,405	52,824	52,095	52,509	51,734	62,041	62,095	61,776	61,785	61,461	61,424
JA	23,286	22,936	4036	3929	47,489	48,220	59,633	58,764	58,850	57,922	58,967	57,976	61,478	61,734	60,695	60,892	60,812	60,947
JH	23,889	23,293	4076	3893	49,425	50,306	60,505	59,092	59,450	57,899	59,591	57,913	63,345	63,643	62,290	62,450	62,431	62,464

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[b] Culling systems: CULL1, open cows were culled at weaning in the fall; CULL2, open cows were culled in the fall and cows without a live calf at the end of the calving season were culled in the spring.

[c] These expenses are in addition to those shown in Table II for weaned calf production.

[d] Includes expenses for weaned calf production (Table II) and additional expenses.

[e] Includes returns from the sale of culled females (Table II) and slaughter calves.

TABLE IV

GROSS MARGIN FOR SELLING CALVES AT WEANING OR SLAUGHTER

	Weaned calves		Slaughter calves					
	Gross margin, $/herd		Gross margin, $/herd					
			Live wt		Carcass wt		Retail cuts	
Crossbred cow group[a]	CULL1[b]	CULL2[b]	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2
HAx	9,568	9,398	13,074	12,872	12,714	12,444	12,093	11,756
SA	9,282	9,021	11,949	11,691	11,691	11,326	11,634	11,172
SH	9,265	8,499	13,086	12,256	12,676	11,789	12,369	11,382
BA	12,054	11,930	14,119	13,987	13,588	13,421	13,145	12,941
BH	11,542	11,000	12,810	12,314	12,546	12,004	12,231	11,643
JA	13,088	12,621	13,989	13,514	13,206	12,672	13,323	12,727
JH	12,860	12,276	13,920	13,338	12,865	12,145	13,006	12,158

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[b] Culling systems: CULL1, open cows were culled at weaning in the fall; CULL2, open cows were culled in the fall and cows without a live calf at the end of the calving season were culled in the spring.

TABLE V

GROSS MARGIN ($/HERD) FOR SELLING CALVES AT WEANING OR SLAUGHTER, ASSUMING A CONSTANT BIRTH RATE OF 90%

Crossbred cow group[a]	Weaned calf production		Slaughter calf production					
			Live wt		Carcass wt		Retail cuts	
	CULL1[b]	CULL2[b]	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2
HAx	9,822	9,664	13,344	13,154	13,020	12,761	12,435	12,107
SA	9,728	9,503	12,412	12,195	12,212	11,881	12,208	11,775
SH	11,633	11,123	15,846	15,295	15,556	14,927	15,484	14,722
BA	12,803	12,638	14,926	14,746	14,475	14,260	14,123	13,869
BH	13,518	13,083	14,635	14,257	14,561	14,127	14,435	13,944
JA	11,954	11,447	12,814	12,301	11,953	11,387	11,957	11,336
JH	12,141	11,530	13,175	12,565	12,072	11,334	12,141	11,284

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[b] Culling systems: CULL1, open cows were culled at weaning in the fall; CULL2, open cows were culled in the fall and cows without a live calf at the end of the calving season were culled in the spring.

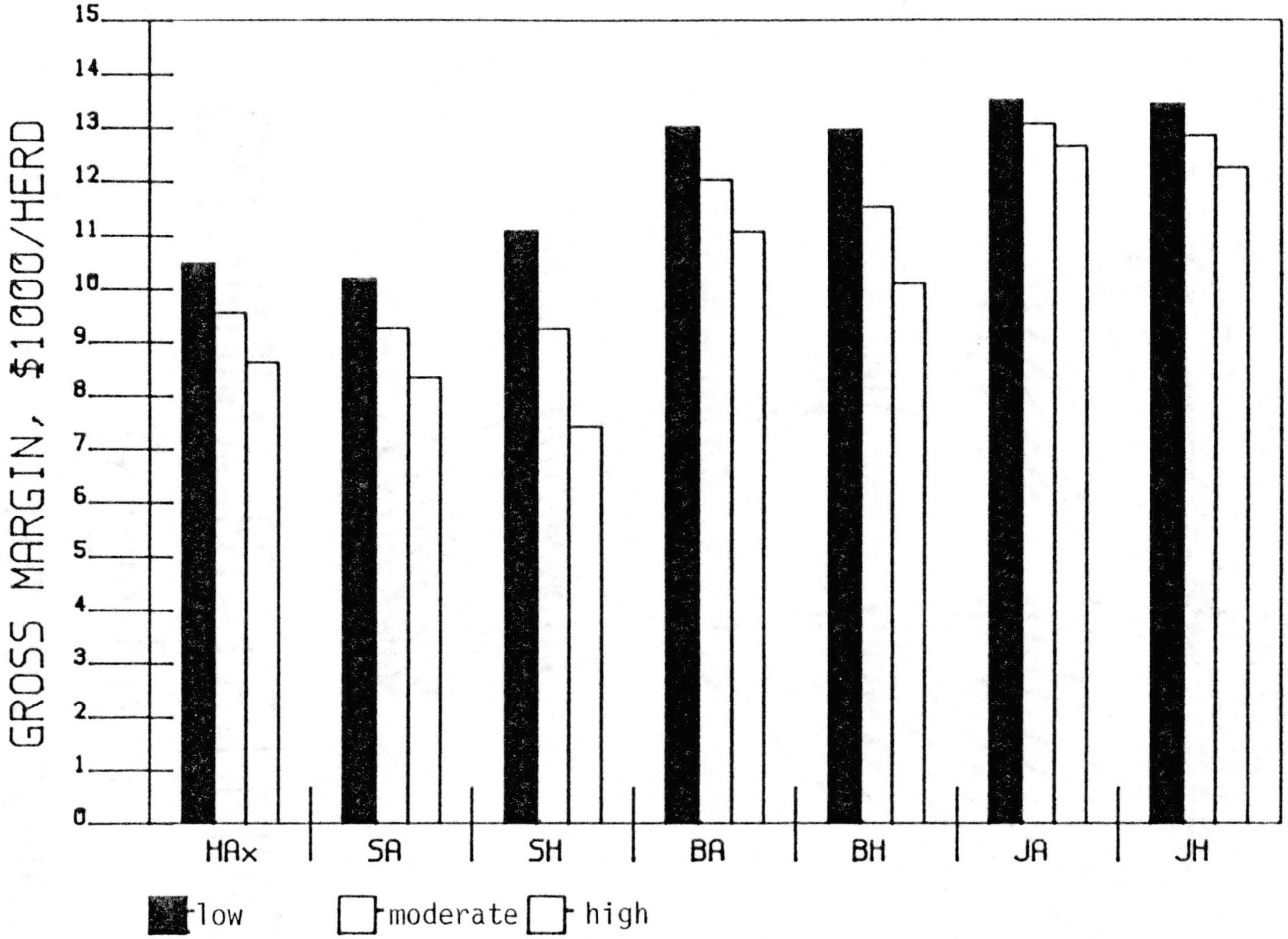

Figure 1. Gross Margins at Low, Moderate and High Replacement Heifer Costs Under Culling System CULL1 When Calves are Sold at Weaning.

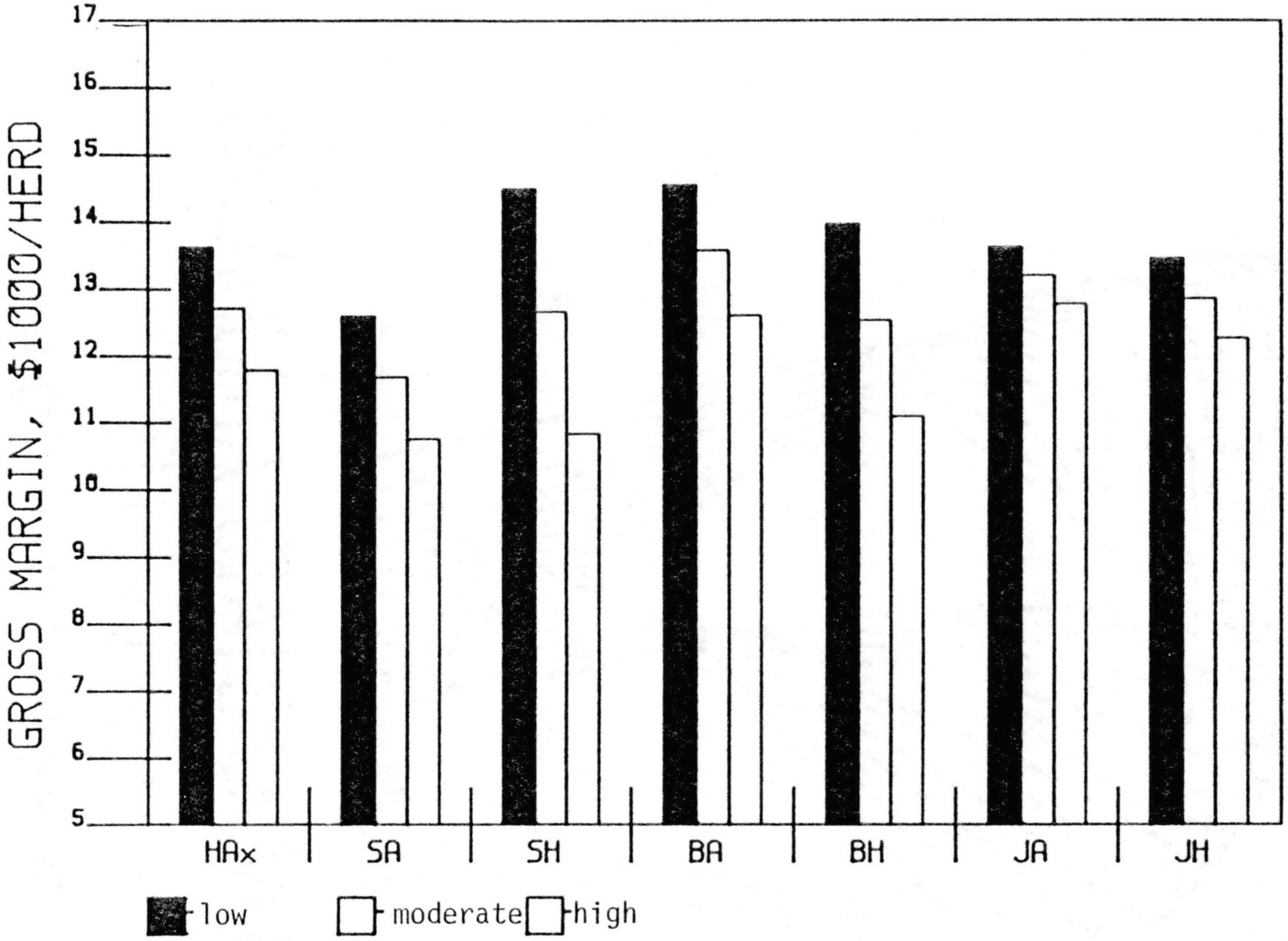

Figure 2. Gross Margins at Low, Moderate and High Replacement Heifer Costs Under Culling System CULL1 When Calves are Sold at Slaughter.

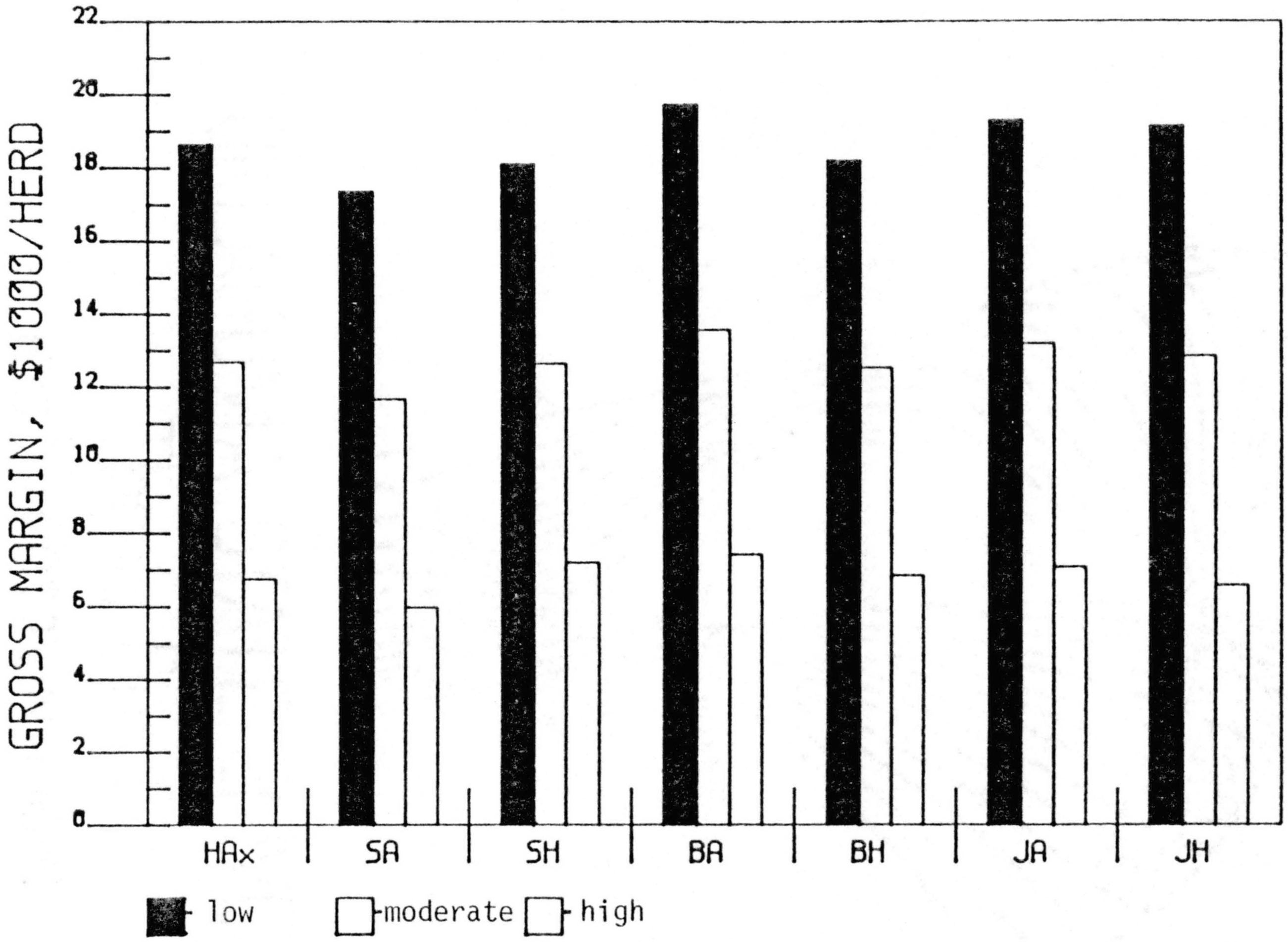

Figure 3. Gross Margins at Low, Moderate and High Costs of Feedlot TDN Under Culling System CULL1 When Calves are Sold at Slaughter.

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APPENDIXES

APPENDIX A

STATISTICAL TABLES

TABLE I

SOURCES OF VARIATION INCLUDED IN REDUCED MODELS FOR CALF PREWEANING TRAITS

	Birth Wt	Calving difficulty		Daily gain	Weaning wt	Weaning Scores	
		Score	%			Condition	Conformation
Calf sire breed (B)	X	X	X	X	X	X	X
Year (Y)/B	X	X	X	X	X	X	X
Sire/Y/B	X	X	X	X	X	X	X
Crossbred cow group (C)	X	X	X	X	X	X	X
Cow age (A)	X	X	X	X	X		X
Calf sex (S)	X	X	X	X	X	X	X
B X C		X	X			X	
B X S							
C X A	X				X		X
C X S							
A X S				X	X		
Birth date				X	X	X	X
Remainder df	1599	1592	1592	1513	1499	1496	1501

[X] Source of variation was included in reduced model.

TABLE II

SOURCES OF VARIATION INCLUDED IN REDUCED MODELS FOR COW PRODUCTIVITY TRAITS

	Cow wt	Calf weaning wt/ Cow wt, kg/kg	Calf weaning wt/ Cow wt$^{.75}$, kg/kg$^{.75}$	Calf weaning wt Per cow exposed, kg/cow
Calf sire breed (B)	X	X	X	X
Year (Y)/B	X	X	X	X
Sire/Y/B	X	X	X	X
Crossbred cow group (C)	X	X	X	X
Cow age (A)	X	X	X	X
Calf sex (S)		X	X	X
B X C				
B X S				
C X A	X			
C X S		X	X	
A X S				X
Birth date	X			X
Remainder df	1502	1509	1509	1513

[X] Source of variation was included in reduced model.

TABLE III

SOURCES OF VARIATION INCLUDED IN REDUCED MODELS FOR FEEDLOT TRAITS

Source	Initial wt	Average daily gain			Final wt	Final age	No. days on feed
		1st 120 d	after 120 d	Overall			
Calf sire breed (B)	X	X	X	X	X	X	X
Year (Y)/B	X	X	X	X	X	X	X
Sire/Y/B	X	X	X	X	X	X	X
Crossbred cow group (C)	X	X	X	X	X	X	X
Cow age (A)	X	X	X	X	X		X
Calf sex (S)	X	X	X	X	X	X	X
B X C							X
B X S		X	X	X	X		
C X A							
C X S		X	X	X			
A X S	X	X	X	X	X		
Initial age	X	X	X	X	X	X	X
Marbing score					X	X	X
Remainder df	1403	1393	1393	1393	1399	1406	1385

[X] Source of variation was included in reduced model.

TABLE IV

SOURCES OF VARIATION INCLUDED IN REDUCED MODELS FOR FEED INTAKE AND FEED EFFICIENCY

	Daily feed intake	Feed/gain
Calf sire breed (B)	X	X
Crossbred Cow group (C)	X	X
Year (Y)	X	X
Calf sex (S)	X	X
B X C		
B X Y		X
B X S		
C X Y		
C X S		
Y X S		X
Remainder df	126	119

[X] Source of variation was included in reduced model.

TABLE V

SOURCES OF VARIATION INCLUDED IN REDUCED MODELS FOR CARCASS WEIGHT TRAITS, FAT THICKNESS AND LONGISSIMUS AREA

Source	Carcass wt	Carcass wt per day of age	Fat thickness	Longissimuss area
Calf sire breed (B)	X	X	X	X
Year (Y)/B	X	X	X	X
Sire/Y/B	X	X	X	X
Crossbred Cow group (C)	X	X	X	X
Dam age (A)	X	X		X
Calf sex (S)	X	X		X
B X C			X	X
B X S	X	X		
C X A				X
C X S		X		
A X S	X	X		
Initial age	X	X		X
Marbing score	X		X	X
Remainder df	1391	1385	1379	1361

[X] Source of variation was included in reduced model.

TABLE VI

SOURCES OF VARIATION INCLUDED IN REDUCED MODELS FOR KHP FAT, DRESSING PERCENTAGE, CUTABILITY, MARBLING SCORE AND QUALITY GRADE

Source	KHP fat	Dressing %	Cutability	Marbling score	Quality grade
Calf sire breed (B)	X	X	X	X	X
Year (Y)/B	X	X	X	X	X
Sire/Y/B	X	X	X	X	X
Crossbred cow group (C)	X	X	X	X	X
Cow age (A)			X	X	X
Calf sex (S)	X	X	X	X	X
B X C				X	X
B X S		X			
C X A			X		
C X S	X			X	X
A X S			X	X	X
Initial age				X	X
Marbing score	X		X		
Remainder df	1392	1397	1381	1367	1367

[X] Source of variation was included in reduced model.

TABLE VII

MEAN SQUARES FROM FULL MODEL ANALYSES OF VARIANCE FOR BIRTH AND WEANING TRAITS OF CALVES

Source	df	Calf birth weight, kg^2	Calving difficulty Score^2	Calving difficulty %^{2}	Avg daily gain, kg^2	Weaning wt, kg^2	Weaning scores Condition	Weaning scores Conformation
Calf sire breed (B)	3	996.8**	8.81**	110.3**	29.24**	19,076**	4.50**	53.8**
Year (Y)/B	10	317.7**	3.03**	35.7**	57.91**	27,006**	6.62**	240.7**
Sire/Y/B	84	65.4**	1.01**	12.2**	1.08*	657**	.28**	6.9**
Crossbred dam group (D)	7	386.9**	1.32*	23.8**	15.70**	7,930**	.37*	87.3**
Dam age (A)	2	243.8**	1.35$^+$	10.5	8.05**	4,871**	.07	29.8**
Calf sex (S)	1	1393.9**	8.34**	60.0**	20.92**	16,621**	.60$^+$	88.8**
B x D	21	15.7	0.80	12.5$^+$	.41	184	.35**	4.8
B x S	3	39.1	0.84	16.0	.11	78	.11	.10
D x A	14	51.0**	0.63	10.7	1.10	638$^+$	.20	7.6**
D x S	7	17.5	0.87	12.6	.91	368	.24	4.2
A x S	2	23.4	0.94	17.4	3.42*	1,716*	.16	2.7
Birth date	1	12.9	0.02	2.8	4.55*	2,846**	24.87**	1008.9**
Remainder	1565(1468)	22.9	0.57	8.6	.79	388	.18	3.5

TABLE VIII

MEAN SQUARES FROM FULL MODEL ANALYSES OF VARIANCE FOR COW PRODUCTIVITY TRAITS

Source	df	Cow wt, kg^2	Weaning wt/ cow wt, (kg/kg)^2	Weaning wt/cow wt$^{.75}$,(kg/kg$^{.75}$)^2	Weaning wt/cow exposed,(kg/cow)^2
Calf sire breed (B)	3	14,033**	13.805**	259.28**	10,586**
Year (Y)/B	10	46,681**	5.125**	130.22**	15,118**
Sire/Y/B	84	1,822	.460^{+}	7.84**	369**
Crossbred dam group (D)	7	82,070**	16.264**	202.79**	9,540**
Dam age (A)	2	60,989**	3.425**	29.78**	2,610**
Calf sex (S)	1	51	9.764**	199.63**	9,592**
B x D	21	1,370	.227	3.23	117
B x S	3	1,922	.097	1.28	77
D x A	14	2,918^{+}	.147	3.21	269
D x S	7	1,302	.610	9.77^{+}	276
A x S	2	2,069	.119	4.89	917*
Birth date	1	16,247**	.065	0.42	1,573**
Remainder	1468	1,856	.364	5.55	217

TABLE IX

MEAN SQUARES FROM FULL MODEL ANALYSES OF VARIANCE FOR FEEDLOT TRAITS

Source	df[a]	Initial wt, kg^2	Average daily gain, (kg/d)^2			Final wt, kg^2	Final age, d^2	No. days on feed, d^2
			1st 120 d	After 120 d	Overall			
Calf sire breed (B)	3	18,832**	93.96**	152.30**	134.74**	87,107**	15,897**	18,333**
Year (Y)/B	10	23,973**	117.58**	160.30**	126.31**	43,358**	35,756**	37,266**
Sire/Y/B	84	575**	7.25**	9.12**	6.56**	3,040**	2,166**	2,202**
Crossbred cow group (C)	7	7,511**	28.11**	20.22**	19.09**	47,724**	4,508**	4,698**
Cow age (A)	2	4,499**	3.37	4.78	.79	1,447	610	2,734*
Calf sex (S)	1	15,151**	469.45**	243.23**	334.12**	439,861**	3,049^{+}	5,107*
B x C	21	168	3.67	4.96	2.06	1,435	1,443	1,437*
B x S	3	148	7.54^{+}	8.25	6.39*	6,613**	1,650	1,768
C x A	14	463	1.45	4.85	1.64	1,214	1,513	1,212
C x S	7	340	4.12	6.64	4.42^{+}	1,567	731	977
A x S	2	2,245**	5.97	28.87**	11.37**	12,406**	1,284	600
Initial age	1	552,019**	56.43**	37.55**	38.05**	105,571**	295,067**	51,205**
Marbling score	(1)			4.98	.78	14,116**	18,188**	19,257**
Remainder	1358(1357)	382	3.27	4.36	2.30	1,425	1,075	879

[a] Number in parentheses represents df for models in which marbling score was included as a covariate.

$^{+}$P<.10, *P<.05, **P<.01.

TABLE X

MEAN SQUARES FROM FULL MODEL ANALYSES OF VARIANCE FOR FEED INTAKE AND CONVERSION

Source	df	Daily feed intake, $(kg/d)^2$	Feed/gain $(kg/kg)^2$
Calf sire breed (B)	2	4.361**	7.13
Crossbred cow group (C)	6	3.459**	33.44**
Year (Y)	4	27.226**	448.16**
Calf sex (S)	1	14.948**	1156.91**
B x C	12	.217	4.34
B x Y	3	.421	51.94**
B x S	2	.086	21.75
C x Y	24	.266	12.14
C x S	6	.547	13.39
Y x S	4	.399	22.84+
Remainder	75	.301	11.24

$^+P<.10$, $^*P<.05$, $^{**}P<.01$.

TABLE XI

MEAN SQUARES FROM FULL MODEL ANALYSES OF VARIANCE FOR CARCASS WEIGHT TRAITS, FAT THICKNESS AND LONGISSIMUS AREA

Source	df[a]	Carcass wt, kg^2	Carcass wt/ d of age $(g/d)^2$	Fat thickness, cm^2	Longissimus area, cm^4
Calf sire breed (B)	3	22,623**	15,716**	545.7**	358,976**
Year (Y)/B	10	14,586**	17,250**	280.1**	80,785**
Sire/Y/B	84	1,404**	1,268**	45.9**	22,799**
Crossbred cow group (C)	7	19,388**	4,171**	19.5	71,797**
Cow age (A)	2	1,262	1,013	2.4	10,598
Calf sex (S)	1	158,543**	58,401**	.4	76,137**
B x C	21	708	415	21.4	$10,340^+$
B x S	3	1,069	$1,190^+$	19.0	6,754
C x A	14	690	221	23.6	12,919*
C x S	7	983	937^+	30.0^+	6,226
A x S	2	3,090*	2,756**	20.5	14,350
Initial age	1	46,020**	11,990**	3.6	142,342**
Marbling score	(1)	8,654**	243	634.7**	$23,867^+$
Remainder	1350(1349)	713	476	16.6	6,884

[a] Number in parentheses represents df for models in which marbling score was included as a covariate.

$^+P<.10$, $*P<.05$, $**P<.01$.

TABLE XII

MEANS SQUARES FROM FULL MODEL ANALYSES OF VARIANCE FOR KHP FAT, DRESSING PERCENTAGE, CUTABILITY MARBLING SCORE AND QUALITY GRADE

Source	df[a]	KHP fat, %	Dressing percentage, %	Cutability, %	Marbling score	Quality grade
Calf sire breed (B)	3	46.88**	1042.2**	877.8**	2.030	3.910
Year (Y)/B	10	36.44**	197.3**	302.1**	5.503**	11.613**
Sire/Y/B	84	8.17**	75.4	62.8**	1.843**	3.324**
Crossbred cow group (C)	7	10.55**	50.5	37.2	.450	1.025
Cow age (A)	2	.87	42.7	3.9	2.800*	5.896**
Calf sex (S)	1	12.30^{+}	154.8	112.8*	.162	1.317
B x C	21	5.47	70.8	19.6	1.516**	2.155*
B x S	3	2.61	173.8^{+}	23.9	.206	.492
C x A	14	4.81	46.0	49.3**	.842	1.708
C x S	7	7.85^{+}	75.3	25.8	1.377*	1.840
A x S	2	8.84	87.1	95.7*	3.031*	3.090^{+}
Initial age	1	0	142.6	0	1.883^{+}	5.230*
Marbling score	(1)	61.54**	158.5	876.4**		
Remainder	1350(1349)	3.95	66.9	22.5	.677	1.180

[a] Number in parentheses represents df for models in which marbling score was included as a covariate.

$^{+}$P<.10, *P<.05, **P<.01.

APPENDIX B

SAS COMPUTER PROGRAM FOR ECONOMIC ANALYSIS

```
OPTIONS NODATE NONUMBER NONOTES;
TITLE ECONOMIC ANALYSIS, PROJECT 1502;
DATA OLD;
INPUT NBD 1 BG 2 BIRWT 4-6 1 DIFF 8-10 2 PDIFF 12-14 3 BTWNADG 16-18 3
WW205 20-22 COWWT 24-26 COWEFF 28-30 1 MEFFKG 32-34 2 OTWT 36-38
DOF 40-42 ADGTOT 44-46 2 FINWT 48-50 FINAGE 52-54 FE 56-58 2
FI 60-62 2 CARCWT 64-66 CUTAB 68-70 1 #2 PBORN 4-6 3 P24 8-10 3
PWEAN 12-14 3 NLTDN 16-18 LTDN 20-23  TOTTDN 25-28 ADJTDN 30-33
MATWT 55-57
NLPD 35-37 2 LPD 39-41 2 TOTPD 43-45 2 ADJPD 47-49 2 DCOWWT 51-53;


***********************************************************************;

*CULLING ALTERNATIVE;
 CULLSYS=1;

*ALTERNATIVE FOR COST OF REPLACEMENT HEIFER;
 ALTREPL=0;

*ALTERNATIVE FOR COST OF FEEDLOT TDN;
 ALTTDNC=0;

*ALTERNATIVE BIRTH RATE (0=GROUP MEAN, 1=CONSTANT OF .9);
 ALTREPRO=0;

*********************************************************************;

*REPRODUCTIVE DATA, 3-9 YR-OLD COWS;

*PBORN = % OF COWS EXPOSED GIVING BIRTH.  THIS IS THE PROPORTION OF
     COW KEPT IN HERD FOLLOWING WEANING (I.E., ASSUMED PREGNANT);
*P24 = % OF COWS EXPOSED WITH A LIVE CALF AT 24 HR;
*PBLIVE = PROPORTION OF PREGNANT COWS WITH A LIVE CALF AT 24 HR.
     COWS WHICH HAD BEEN DIAGNOSED PREGNANT BUT FAIL TO PRODUCE A
     LIVE CALF AT 24 HR ARE CULLED IN SPRING. HENCE, PBLIVE = THE
     PROPORTION OF THE "PREGNANT HERD" OR "CALVING HERD"
     KEPT UNTIL WEANING IN THE FALL AND ARE CREDITED WITH CONSUM-
     ING TDN FULL YR;
*PWEAN = % OF COWS EXPOSED PRODUCING A WEANED CALF;
*P24WEAN = PROPORTION OF HERD KEPT FULL YR WHICH PRODUCE A CALF
     AT WEANING;
*PBWEAN= % OF THE "PREGNANT HERD" PRODUCING A CALF AT WEANING;


PBLIVE=P24/PBORN;
P24WEAN=PWEAN/P24;
PBWEAN=PWEAN/PBORN;

*BASE PERCENT WEANED = 80 % FOR HA, AH;

  WEANCORR=.80/.746;
  PWEAN=PWEAN*WEANCORR;
```

```
  PBORN=PWEAN/PBWEAN;
  P24=PBORN*PBLIVE;

*--------------------------------------------------------------------;
*REPRODUCTIVE DATA, 2-YR-OLD COWS (BELCHER AND FRAHM, 1979);

IF BG=1 THEN DO;
   PBORN2=.865;
   PDIFF2=.312;
   P242=.769;
   PWEAN2=.720;
END;
IF BG=3 THEN DO;
   PBORN2=.812;
   PDIFF2=.357;
   P242=.724;
   PWEAN2=.724;
END;
IF BG=4 THEN DO;
   PBORN2=.578;
   PDIFF2=.500;
   P242=.556;
   PWEAN2=.533;
END;
IF BG=5 THEN DO;
   PBORN2=.936;
   PDIFF2=.182;
   P242=.872;
   PWEAN2=.851;
END;
IF BG=6 THEN DO;
   PBORN2=.780;
   PDIFF2=.282;
   P242=.760;
   PWEAN2=.720;
END;
IF BG=7 THEN DO;
   PBORN2=.898;
   PDIFF2=.207;
   P242=.881;
   PWEAN2=.881;
END;
IF BG=8 THEN DO;
   PBORN2=.949;
   PDIFF2=.179;
   P242=.915;
PWEAN2=.915;
END;

PBLIVE2=P242/PBORN2;
P24WEAN2=PWEAN2/P242;
PBWEAN2=PWEAN2/PBORN2;

************************************************;

*ALTERNATE BIRTH RATE;

 IF ALTREPRO=1 THEN DO;
```

```
    PBORN=.9;           PBORN2=.9;
    PWEAN=PBORN*PBWEAN; PWEAN2=PBORN2*PBWEAN2;
    P24=PBORN*PBLIVE;   P242=PBORN2*PBLIVE2;
 END;

*************************************************;

*WEIGHTS OF YEARLING HEIFERS;

IF BG=1 THEN YHW=222;
IF BG=3 THEN YHW=250;
IF BG=4 THEN YHW=231;
IF BG=5 THEN YHW=241;
IF BG=6 THEN YHW=227;
IF BG=7 THEN YHW=212;
IF BG=8 THEN YHW=212;

*WEIGHTS OF CULLED REPLACEMENT HEIFERS (1YR, 205 D OLD);

IF BG=1 THEN HW=266;
IF BG=3 THEN HW=299;
IF BG=4 THEN HW=278;
IF BG=5 THEN HW=286;
IF BG=6 THEN HW=273;
IF BG=7 THEN HW=253;
IF BG=8 THEN HW=251;

*SPRING WEIGHTS OF 2-YR-OLD COWS;
IF BG=1 THEN SW=300;
IF BG=3 THEN SW=337;
IF BG=4 THEN SW=314;
IF BG=5 THEN SW=322;
IF BG=6 THEN SW=309;
IF BG=7 THEN SW=285;
IF BG=8 THEN SW=282;

*FALL WEIGHTS OF 2-YR-OLD COWS;

IF BG=1 THEN COWWT2=343;
IF BG=3 THEN COWWT2=381;
IF BG=4 THEN COWWT2=362;
IF BG=5 THEN COWWT2=360;
IF BG=6 THEN COWWT2=348;
IF BG=7 THEN COWWT2=316;
IF BG=8 THEN COWWT2=321;

*PERFORMANCE TO WEANING OF CALVES FROM 2-YR-OLD COWS;

IF BG=1 THEN DO; PDIFF2=.312; WW2052=168; END;
IF BG=3 THEN DO; PDIFF2=.357; WW2052=192; END;
IF BG=4 THEN DO; PDIFF2=.500; WW2052=187; END;
IF BG=5 THEN DO; PDIFF2=.182; WW2052=203; END;
IF BG=6 THEN DO; PDIFF2=.282; WW2052=192; END;
IF BG=7 THEN DO; PDIFF2=.207; WW2052=189; END;
IF BG=8 THEN DO; PDIFF2=.179; WW2052=189; END;

***********************************************************************;
```

```
*COW DEATH LOSS;

  COWLOSS=.02;          *ANNUAL COW DEATH LOSS = 2 %;
  SCOWLOSS=COWLOSS/2;   *HALF THE COW DEATH LOSS IS ASSUMED TO OCCUR IN
                         THE SPRING AND HALF IN THE FALL.  SCOWLOSS IS
                         THE SPRING LOSS;
  FCOWLOSS=SCOWLOSS;    *FALL COW DEATH LOSS OCCURS JUST PRIOR TO WEANING
;

*****************************************************************;



*COW HERD FEED REQUIREMENTS, 3-9 YR-OLD COWS;

*THESE ARE PREDICTED TDN INTAKES - BASED ON DRYLOT INTAKES, BUT
     CORRECTED FOR DIFFERENCES IN WEIGHT AND MILK PRODUCTION BETWEEN
     DRYLOT VS RANGE COWS.  THE DIFFERENCE IS BASED ON NRC;

  IF BG=1 THEN TDN160=683.3; IF BG=1 THEN TDN205=1175.3;
  IF BG=3 THEN TDN160=774.4; IF BG=3 THEN TDN205=1358.2;
  IF BG=4 THEN TDN160=736.5; IF BG=4 THEN TDN205=1274.9;
  IF BG=5 THEN TDN160=740.4; IF BG=5 THEN TDN205=1250.1;
  IF BG=6 THEN TDN160=712.3; IF BG=6 THEN TDN205=1256.1;
  IF BG=7 THEN TDN160=673.2; IF BG=7 THEN TDN205=1251.5;
  IF BG=8 THEN TDN160=667.6; IF BG=8 THEN TDN205=1191.0;

  IF BG=1 THEN GTDN=58.6;
  IF BG=3 THEN GTDN=62.6;
  IF BG=4 THEN GTDN=63.0;
  IF BG=5 THEN GTDN=60.1;
  IF BG=6 THEN GTDN=61.0;
  IF BG=7 THEN GTDN=49.6;
  IF BG=8 THEN GTDN=50.5;

*TDN FROM SUPPLEMENT HAS BEEN SUBTRACTED IN THE FOLLOWING;
 IF BG=1 THEN TDN160=457.0; IF BG=1 THEN TDN205=1056.0;
 IF BG=3 THEN TDN160=494.0; IF BG=3 THEN TDN205=1208.6;
 IF BG=4 THEN TDN160=495.0; IF BG=4 THEN TDN205=1146.0;
 IF BG=5 THEN TDN160=470.0; IF BG=5 THEN TDN205=1117.8;
 IF BG=6 THEN TDN160=478.7; IF BG=6 THEN TDN205=1126.0;
 IF BG=7 THEN TDN160=403.6; IF BG=7 THEN TDN205=1095.4;
 IF BG=8 THEN TDN160=406.9; IF BG=8 THEN TDN205=1050.6;

NL205=(TDN160-GTDN)/160*205;   *INTAKE OF COWS WHICH LOST THEIR CALVES W/
                                 N 24 H OF BIRTH (DRY COWS) DURING THE
                                 PERIOD FROM BIRTH TO WEANING;
                                 *SINCE TDN160 WAS BASED ON PREGNANT
                                  COWS, THE GESTATION REQUIREMENT
                                  WAS SUBTRACTED PRIOR TO LINEAR
                                  ADJUSTMENT TO 205 D DRY PERIOD;


*----------------------------------------------------------------;

*TDN REQUIREMENTS FOR YEARLING AND 2-YR-OLD REPLACEMENTS (NRC, 1974);

IF BG=1 THEN DO;  T1=680;
```

```
T2A=589;  T2B=537;  T3A=1019;  T3B=769;
END;
IF BG=3 THEN DO;  T1=767;
T2A=659;  T2B=603;  T3A=1218;  T3B=837;
END;
IF BG=4 THEN DO;  T1=719;
T2A=622;  T2B=566;  T3A=1139;  T3B=820;
END;
IF BG=5 THEN DO;  T1=729;
T2A=625;  T2B=571;  T3A=1211;  T3B=777;
END;
IF BG=6 THEN DO;  T1=702;
T2A=607;  T2B=553;  T3A=1186;  T3B=759;
END;
IF BG=7 THEN DO; T1=643;
T2A=553;  T2B=505;  T3A=1073;  T3B=675;
END;
IF BG=8 THEN DO;  T1=634;
T2A=543;  T2B=495;  T3A=1084;  T3B=712;
END;

*-----------------------------------------------------------;


*UNDER CULLING SYSTEM 1, ALL OPEN COWS ARE CULLED AT WEANING TIME
IN OCT, SO THAT THE LACTATING PORTION OF THE INTAKE EQUATION TDN4
IS WEIGHTED BY PBLIVE (HALF THE ANNUAL DEATH LOSS HAS ALSO
OCCURRED).  THE LAST TERM IN THE EQUATION IS THE INTAKE OF COWS
WHICH LOST THEIR CALVES W/N 24 H AFTER BIRTH (I.E., NON-LAC INTAKE);

*EXECUTES ONLY FOR CULLING SYSTEM 2;
IF CULLSYS=2 THEN DO;
   NL205=0; T3B=0; END;

TDN3YR = TDN160+(1-SCOWLOSS)*PBLIVE*TDN205+(1-SCOWLOSS)*(1-PBLIVE)*NL205
;
TDN2YR = (T1/PBORN2) + T2A + (1-SCOWLOSS)*PBLIVE2*T3A +
         (1-SCOWLOSS)*(1-PBLIVE2)*T3B;

MCULL=.01;    *MANAGEMENT CULLS = 1 % OF HERD REMAINING AT WEANING;

RR=1-(1-SCOWLOSS)*(1-FCOWLOSS)*(1-MCULL)*PBORN;  *REPLACEMENT RATE;
   *1-RR = PROPORTION OF HERD RETAINED;

IF CULLSYS=2 THEN DO;
   RR=1-((1-RR)*PBLIVE);
   END;

P2YR=RR*(1+SCOWLOSS);  *PROPORTION OF HERD CALVING THAT IS 2-YR-OLD;
P3YR=(1-RR)*(1+SCOWLOSS);  *PROPORTION OF HERD CALVING THAT IS
                                   3-9 YR-OLD;
TDN=(P2YR*TDN2YR)+(P3YR*TDN3YR);  *ANNUAL TDN PER COW CALVING;

*CARRYING CAPACITY;

  *THE BASE TDN RESTRICTION IS ARBITRARILY CHOSEN AS THE AMOUNT WHICH
   SUPPORTS 100 COWS CALVING FOR BREED GROUP 1 (HA IN THIS STUDY);
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```
IF BG=1 THEN DO;
   BASETDN=TDN*100;
   RETAIN BASETDN;
END;
CC=BASETDN/TDN;  *NO. OF COWS CALVING;
NR=RR*CC;  *NO. OF 2-YR-OLD COWS CALVING;
NP=(1-RR)*CC;  *NO. OF 3-9 YR-OLD COWS CALVING;
NY=(NR/.99)/PBORN2;  *NO. OF YEARLING REPLACEMENT HEIFERS PURCHASED
                       IN THE SPRING.  ACCOUNTS FOR SUBSEQUENT 1 %
                       DEATH LOSS AND PREGNANCY RATE;
NCW2=NR*PBWEAN2*(1-FCOWLOSS);  *NO. OF CALVES WEANED FROM 2-YR-OLD COWS.
                        TAKES IN ACCOUNT FALL DEATH LOSS;
NCW3=NP*PBWEAN*(1-FCOWLOSS);  *NO. OF CALVES WEANED FROM 3-9 YR-OLD COWS
                               ;
NYSOLD=NY*(1-PBORN2);  *NO. OF YEARLING HEIFERS (OPEN CULLS) SOLD;
N2OPEN=NR*(1-FCOWLOSS)*(1-PBORN); *NO. OF OPEN 2-YR-OLD CULLS;
N3OPEN=NP*(1-FCOWLOSS)*(1-PBORN); *NO. OF OPEN 3-9 YR-OLD CULLS;
**********************************************************************;
N2MCULL=NR*(1-FCOWLOSS)*PBORN*MCULL; *NO. OF 2-YR-OLD MANAGEMENT CULLS;
N3MCULL=NP*(1-FCOWLOSS)*PBORN*MCULL; *NO. OF 3-9 YR-OLD MANAGEMENT CULLS
; N2SOLD=N2OPEN+N2MCULL; *NO. OF 2-YR-OLD CULLS SOLD;
N3SOLD=N3OPEN+N3MCULL; *NO. OF 3-9 YR-OLD CULLS SOLD;

IF CULLSYS=2 THEN DO;
  N2CULLSP=NR*(1-PBLIVE2);
  N3CULLSP=NP*(1-PBLIVE);
  N2OPEN=NCW2*(1-PBORN);
  N3OPEN=NCW3*(1-PBORN);
  N2MCULL=NCW2*PBORN*MCULL;
  N3MCULL=NCW3*PBORN*MCULL;
  N2SOLD=N2CULLSP+N2OPEN+N2MCULL;
  N3SOLD=N3CULLSP+N3OPEN+N3MCULL;
END;

*----------------------------------------------------------;

*KG CALF WEIGHT WEANED;
 WNWT2=NCW2*WW2052;    *FROM 2-YR-OLD COWS;
 WNWT3=NCW3*WW205;     *FROM 3-9 YR-OLD COWS;
 WNWT=WNWT2+WNWT3;     *TOTAL;
*KG CULL COW WEIGHT SOLD;
 NYWTS=NYSOLD*HW;      *FROM NONPREGNANT HEIFERS;
 N2WTS=N2SOLD*COWWT2;  *FROM 2-YR-OLD COWS;
 IF CULLSYS=2 THEN DO;
    N2WTS=(N2CULLSP*SW)+((N2OPEN+N2MCULL)*COWWT2); END;
 N3WTS=N3SOLD*COWWT;
 CULLWT=NYWTS+N2WTS+N3WTS;

NCE=NY+NP;  *NO. COWS EXPOSED TO BREEDING;

**********************************************************************;

*BREEDING HERD FEED COSTS;
    TDN160C=.09274;     *UNIT = $ / KG TDN;
    TDN205C=.09010;     *UNIT = $ / KG TDN;
    MIN160C=4.38;       *SALT-MINERAL COST, UNIT = $ / COW;
    MIN205C=5.62;       *SALT-MINERAL COST, UNIT = $ / COW;
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    TDNC=.5*(TDN160C+TDN205C);  *AVG TDN COST, $ PER KG;
     CSMC=.2692; *COST OF COTTON SEED MEAL, $/KG DM;
     HAYC=.0441; *COST OF BERMUDA HAY, $/KG DM;

************************************************************************;



*ASSUMED CATTLE PRICES - AVG PRICES FOR 1977-82;

SLHEIFPR=1.3150;   *CH- SLAUGHTER CALF PRICE = $1.315/KG LIVE WT;

SLCALFPR=1.3340;  *CH- SLAUGHTER CALF PRICE = $1.3340/KG LIVE WT;
SPRCOWPR=.8627;    *MARCH COW PRICE = $.8627/KG LIVE WT;
FALCOWPR=.7908;    *OCTOBER COW PRICE = $.7908/KG LIVE WT;
COWPR=.8610; *ANNUAL AVG WEIGHTED PRICE: .7(UTILITY, COMMERCIAL)
              + .3(CANNER, CUTTER);
WNCALFPR=1.4387;  *OCTOBER WEANED CALF PRICE = $1.4387/KG LIVE WT;
YRHEIFPR=1.3009*1.10;  *MARCH FEEDER HEIFER PRICE TIMES PREMIUM;
CWPR=2.0876; *CARCASS WEIGHT PRICE (LIVE PRICE/AVG DP);
RCPR=4.2089; *PRICE PER KG BONELESS, CLOSELY TRIMMED RETAIL CUTS;
             *(CARCASS PRICE/AVG CUTABILITY);

*************************************************************;

*REVENUE FROM COW-CALF SEGMENT;

NYR=NYSOLD*HW*SLHEIFPR; *SALVAGE REVENUE FROM YEARLING CULLS;
N2R=N2SOLD*COWWT2*COWPR; *SALVAGE REVENUE FROM 2-YR-OLD CULLS;
  IF CULLSYS=2 THEN DO;
     SP2R=N2CULLSP*SW*COWPR;
     SP3R=N3CULLSP*COWWT*COWPR;
     SPR=SP2R+SP3R;
     N2R=((N2CULLSP*SW)+((N2OPEN+N2MCULL)*COWWT2))*COWPR;
    END;
N3R=N3SOLD*COWWT*COWPR; *SALVAGE REVENUE FROM 3-9 YR-OLD CULLS;
CULLR=NYR+N2R+N3R; *TOTAL SALVAGE REVENUE FROM CULLED FEMALES;


WNCALF2R=NCW2*WW2052*WNCALFPR; *REVENUE FROM SALE OF WEANED CALVES
                                FROM 2-YR-OLD COWS;
WNCALF3R=NCW3*WW205*WNCALFPR;  *REVENUE FROM SALE OF WEANED CALVES
                                FROM 3-9 YR-OLD COWS;
CALFR=WNCALF2R+WNCALF3R; *REVENUE FROM SALE OF ALL WEANED CALVES;

COWCALFR=CULLR+CALFR; *TOTAL REVENUE FROM COW-CALF SEGMENT WHEN
                       CALVES ARE SOLD AT WEANING (FROM WEANED
                       CALVES AND CULLED FEMALES);

************************************************************************;
*SUPPLEMENT;
IF BG=1 THEN DO;
   CSMNL=156; CSML=83.3; HAYNL=227.1; HAYL=117.7; END;
IF BG=3 THEN DO;
   CSMNL=162; CSML=91.1; HAYNL=330.2; HAYL=166.9; END;
IF BG=4 THEN DO;
   CSMNL=162; CSML=88.2; HAYNL=251.0; HAYL=130.8; END;
IF BG=5 THEN DO;
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   CSMNL=158; CSML=92.4; HAYNL=315.6; HAYL=133.8; END;                  00003909
IF BG=6 THEN DO;                                                        00003910
   CSMNL=159.6; CSML=90.7; HAYNL=236.7; HAYL=129.2; END;                00003911
IF BG=7 THEN DO;                                                        00003912
   CSMNL=147.3; CSML=87.3; HAYNL=331.0; HAYL=189.8; END;                00003913
IF BG=8 THEN DO;                                                        00003914
   CSMNL=147.8; CSML=85.1; HAYNL=312.9; HAYL=159.6; END;                00003915
*-------------------------------------------------------;               00003916
CCSMNL=CSMNL*CSMC;    *COST OF CSM PER COW FOR NONLAC;                  00003918
CHAYNL=HAYNL*HAYC;    *COST OF HAY PER COW FOR NONLAC;                  00003919
CCSML=CSML*CSMC;      *COST OF CSM PER COW FOR LAC;                     00003920
CHAYL=HAYL*HAYC;      *COST OF HAY PER COW FOR LAC;                     00003921
CSUPPNL=CCSMNL+CHAYNL; *COST PER COW FOR CSM AND HAY, NONLAC;           00003922
CSUPPL=CCSML+CHAYL;     *COST PER COW FOR CSM AND HAY, LAC;             00003923
SUPP1=CC*CSUPPNL;       *TOTAL COST FOR NONLAC;                         00003924
SUPP2=0;                                                                00003925
ESUPP=CC*(CSUPPNL+CSUPPL);                                              00003926
 IF CULLSYS=2 THEN DO;                                                  00003927
    ESUPP=(CC*CSUPPNL)+(CC-N2CULLSP-N3CULLSP)*CSUPPL;                   00003928
    SUPP2=(CC-N2CULLSP-N3CULLSP)*CSUPPL;                                00003929
 END;                                                                   00003930
                                                                        00003940
 ENY=NY*YHW*YRHEIFPR;  *TOTAL EXPENSE OF PURCHASING YRLING REPLACEMENTS;00003957
                                                                        00003958
*-------------------------------------------;                           00003959
 *ALTERNATE REPLACEMENT HEIFER COST;                                    00003960
  IF ALTREPL=1 THEN DO;                                                 00003970
     ENY=ENY-(NY*50); END;                                              00003980
  IF ALTREPL=2 THEN DO;                                                 00003990
     ENY=ENY+(NY*50); END;                                              00004000
*-------------------------------------------;                           00004010
                                                                        00004020
 CDIFF=20;  *COST OF A DIFFICULT CALVING;                               00004030
 EDIFF=((NR*PDIFF2)+(NP*PDIFF))*CDIFF;  *TOTAL COST OF CALVING          00004040
                                         DIFFICULTY;                    00004050
 CBULL=15.60;  *BULL COST PER COW EXPOSED TO BREEDING;                  00004060
 EBULL=NCE*CBULL;  *TOTAL BULL EXPENSE;                                 00004070
 OTHERNF=50;  *OTHER NON-FEED COSTS PER COW CALVING: VET-MED, HAULING   00004080
              & MARKETING, PERSONAL TAXES, SUPPLIES & UTILITIES,        00004090
              MACHINERY & EQUIPMENT, LABOR (OSU ENTERPRISE BUDGETS,     00004100
              OSU EXTENSION SERVICE, 1980);                             00004110
 OTHERNFY=OTHERNF*(205/365); *OTHER NON-FEED COSTS FOR YEARLING REPL-   00004120
              ACEMENTS (THESE ENTER COW HERD OR ARE SOLD AFTER 205);    00004130
 EOTHERY=OTHERNFY*NY; *BREED GROUP TOTAL FOR OTHER NON-FEED COSTS       00004140
              FOR YEARLING HEIFERS;                                     00004150
 EOTHER=OTHERNF*(NP+NR); *BREED GROUP TOTAL FOR OTHER NON-FEED COSTS    00004160
              FOR COWS;                                                 00004170
                                                                        00004180
   IF CULLSYS=2 THEN DO;                                                00004190
      OTHERSP=30;  *OTHER NON-FEED COSTS FOR COWS CULLED IN SPRING;     00004200
 EOTHER=OTHERSP*(N2CULLSP+N3CULLSP)+OTHERNF*(NP+NR-N2CULLSP-N3CULLSP);  00004210
END;                                                                    00004220
                                                                        00004230
*------------------------------------------------------------;          00004240
*CALCULATION OF INTEREST CHARGES FOR COW-CALF SEGMENT;                  00004250
                                                                        00004260
*TDN EXPENSE FOR COW HERD IS NOT NEEDED (ASSUMING NO SEASONAL DIFFERENCE00004270
 IN THE COST OF FEED) SINCE IT'S THE SAME FOR EACH BREED GROUP.  HOWEVER00004280
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 INTEREST ON THE FEED MAY VARY DEPENDING ON HERD DISTRIBUTION, BECAUSE
 REPLACEMENT HEIFERS MUST BE MAINTAINED FOR 205 D BEFORE ENTERING THE
 HERD;
*BREED GROUP TOTAL FOR EACH CATEGORY OF FEED IS CALCULATED SO IT MAY
 THEN BE PARTITIONED INTO MONTHLY SEGMENTS;
 TDN1=TDN160*P3YR*CC;
 TDN2=TDN205*(1-SCOWLOSS)*PBLIVE*P3YR*CC;
 TDN3=NL205*(1-SCOWLOSS)*(1-PBLIVE)*P3YR*CC;
 TDN4=(T1/PBORN2)*P2YR*CC;
 TDN5=T2A*P2YR*CC;
 TDN6=T3A*(1-SCOWLOSS)*PBLIVE2*P2YR*CC;
 TDN7=T3B*(1-SCOWLOSS)*(1-PBLIVE2)*P2YR*CC;
 TDNSUM=SUM(OF TDN1-TDN7); *CHECK TO SEE IF SUM = BASETDN;
*HAVE DECIDED NOT TO CHARGE INTEREST ON PASTURE;
 TDN1=0; TDN2=0; TDN3=0; TDN4=0; TDN5=0; TDN6=0; TDN7=0;

*CALCULATION OF COSTS PARTITIONED INTO APPROPRIATE MONTHLY SEGMENTS;
 COCT1=TDN1*(31/160)*TDNC;
 COCT2=TDN5*(31/160)*TDNC;
 COCT3=EOTHER*(31/365);
  SUMCOCT=SUM(OF COCT1-COCT3);
 CNOV1=TDN1*(30/160)*TDNC;
 CNOV2=TDN5*(30/160)*TDNC;
 CNOV3=EOTHER*(30/365);
CNOV4=SUPP1*(30/129);
  SUMCNOV=SUM(OF CNOV1-CNOV4);
 CDEC1=TDN1*(31/160)*TDNC;
 CDEC2=TDN5*(31/160)*TDNC;
 CDEC3=EOTHER*(31/365);
  CDEC4=SUPP1*(31/129);
  SUMCDEC=SUM(OF CDEC1-CDEC4);
 CJAN1=TDN1*(31/160)*TDNC;
 CJAN2=TDN5*(31/160)*TDNC;
 CJAN3=EOTHER*(31/365);
 CJAN4=SUPP1*(31/129);
  SUMCJAN=SUM(OF CJAN1-CJAN4);
 CFEB1=TDN1*(28/160)*TDNC;
 CFEB2=TDN5*(28/160)*TDNC;
 CFEB3=EOTHER*(28/365);
 CFEB4=SUPP1*(28/129);
SUMCFEB=SUM(OF CFEB1-CFEB4);
 CMAR1=TDN1*(9/160)*TDNC;
 CMAR2=TDN2*(22/205)*TDNC;
 CMAR3=TDN3*(22/205)*TDNC;
 CMAR4=TDN4*(22/205)*TDNC;
 CMAR5=TDN5*(9/205)*TDNC;
 CMAR6=TDN6*(22/205)*TDNC;
 CMAR7=TDN7*(22/205)*TDNC;
 CMAR8=ENY;
 CMAR9=EDIFF;
 CMAR10=EOTHER*(31/365);
 CMAR11=EOTHER*(22/205);
 CMAR12=SUPP1*(9/129);
 CMAR13=SUPP2*(22/50);
  SUMCMAR=SUM(OF CMAR1-CMAR13);

    IF CULLSYS=2 THEN DO;
       SUMCMAR=SUMCMAR-SPR;  END;  *NOTE SUBTRACTION OF REVENUE
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        FROM SELLING IN THE SPRING COWS WHICH LOST THEIR CALVES;

 CAPR1=TDN2*(30/205)*TDNC;
 CAPR2=TDN3*(30/205)*TDNC;
 CAPR3=TDN4*(30/205)*TDNC;
 CAPR4=TDN6*(30/205)*TDNC;
 CAPR5=TDN7*(30/205)*TDNC;
 CAPR6=EOTHER*(30/365);
 CAPR7=EOTHERY*(30/205);
 CAPR8=SUPP2*(28/50);
  SUMCAPR=SUM(OF CAPR1-CAPR8);
 CMAY1=TDN2*(31/205)*TDNC;
 CMAY2=TDN3*(31/205)*TDNC;
 CMAY3=TDN4*(31/205)*TDNC;
 CMAY4=TDN6*(31/205)*TDNC;
 CMAY5=TDN7*(31/205)*TDNC;
 CMAY6=EBULL;
 CMAY7=EOTHER*(31/365);
 CMAY8=EOTHERY*(31/205);
 SUMCMAY=SUM(OF CMAY1-CMAY8);
 CJUN1=TDN2*(30/205)*TDNC;
 CJUN2=TDN3*(30/205)*TDNC;
 CJUN3=TDN4*(30/205)*TDNC;
 CJUN4=TDN6*(30/205)*TDNC;
 CJUN5=TDN7*(30/205)*TDNC;
 CJUN6=EOTHER*(30/365);
 CJUN7=EOTHERY*(30/205);
 SUMCJUN=SUM(OF CJUN1-CJUN7);
 CJUL1=TDN2*(31/205)*TDNC;
 CJUL2=TDN3*(31/205)*TDNC;
 CJUL3=TDN4*(31/205)*TDNC;
 CJUL4=TDN6*(31/205)*TDNC;
 CJUL5=TDN7*(31/205)*TDNC;
 CJUL6=EOTHER*(31/365);
 CJUL7=EOTHERY*(31/205);
  SUMCJUL=SUM(OF CJUL1-CJUL7);
 CAUG1=TDN2*(31/205)*TDNC;
 CAUG2=TDN3*(31/205)*TDNC;
 CAUG3=TDN4*(31/205)*TDNC;
 CAUG4=TDN6*(31/205)*TDNC;
 CAUG5=TDN7*(31/205)*TDNC;
 CAUG6=EOTHER*(31/365);
 CAUG7=EOTHERY*(31/205);
  SUMCAUG=SUM(OF CAUG1-CAUG7);
 CSEP1=TDN2*(30/205)*TDNC;
 CSEP2=TDN3*(30/205)*TDNC;
 CSEP3=TDN4*(30/205)*TDNC;
 CSEP4=TDN6*(30/205)*TDNC;
 CSEP5=TDN7*(30/205)*TDNC;
 CSEP6=EOTHER*(30/365);
 CSEP7=EOTHERY*(30/205);
  SUMCSEP=SUM(OF CSEP1-CSEP7);

AI=.13;  *ANNUAL INTEREST RATE;
S1=SUMCOCT;  *CUMULATIVE CASH FLOW, OCTOBER;
   I1=S1*AI*(31/365);  *OCTOBER INTEREST EXPENSE;
S2=S1+I1+SUMCNOV;      *CUMULATIVE CASH FLOW, NOVEMBER;
   I2=S2*AI*(30/365);     *NOVEMBER INTEREST EXPENSE;
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S3=S2+I2+SUMCDEC;          *CUMULATIVE CASH FLOW, DECEMBER;
   I3=S3*AI*(31/365);      *DECEMBER INTEREST EXPENSE;
S4=S3+I3+SUMCJAN;          *CUMULATIVE CASH FLOW, JANUARY;
   I4=S4*AI*(31/365);      *JANUARY INTEREST EXPENSE;
S5=S4+I4+SUMCFEB;          *CUMULATIVE CASH FLOW, FEBRUARY;
   I5=S5*AI*(28/365);      *FEBRUARY INTEREST EXPENSE;
S6=S5+I5+SUMCMAR;           *CUMULATIVE CASH FLOW, MARCH;
   I6=S6*AI*(31/365);       *MARCH INTEREST EXPENSE;
S7=S6+I6+SUMCAPR;           *CUMULATIVE CASH FLOW, APRIL;
   I7=S7*AI*(30/365);       *APRIL INTEREST EXPENSE;
S8=S7+I7+SUMCMAY;           *CUMULATIVE CASH FLOW, MAY;
   I8=S8*AI*(31/365);       *MAY INTEREST EXPENSE;
S9=S8+I8+SUMCJUN;           *CUMULATIVE CASH FLOW, JUNE;
   I9=S9*AI*(30/365);       *JUNE INTEREST EXPENSE;
S10=S9+I9+SUMCJUL;          *CUMULATIVE CASH FLOW, JULY;
   I10=S10*AI*(31/365);     *JULY INTEREST EXPENSE;
S11=S10+I10+SUMCAUG;        *CUMULATIVE CASH FLOW, AUGUST;
   I11=S11*AI*(31/365);     *AUGUST INTEREST EXPENSE;
S12=S11+I11+SUMCSEP;        *CUMULATIVE CASH FLOW, SEPTEMBER;
   I12=S12*AI*(30/365);     *SEPTEMBER INTEREST EXPENSE;

*--------------------------------------------------------------;

EI=SUM(OF I1-I12);  *ANNUAL INTEREST EXPENSE - INCLUDES INTEREST ON
                     ALL COSTS EXCEPT BASE COW HERD;

ECOWCALF=ENY+EDIFF+EBULL+EOTHERY+EOTHER+EI+ESUPP;   *TOTAL COW-CALF EXP
              ABOVE BASE LAND AND COW HERD INVESTMENT;

 ECOWOP=ECOWCALF-ENY; *TOTAL NON-LAND OPERATING COSTS FOR COW HERD;
**********************************************************;

*PROFIT EQUATIONS FOR SELLING CALVES AT WEANING;

 PROFW=COWCALFR-ECOWCALF; *TOTAL PROFIT OF COW-CALF SEGMENT PER 1000
       ACRES LAND (ABOVE BASE LAND AND COW HERD COST);

*-------------------------------------------------------------------;
*CALCULATIONS FROM COW-CALF SEGMENT BASED ON REDUCED PRICE FOR J CROSSES
;
IF BG=7 OR BG=8 THEN ADJWNPR=WNCALFPR*.9;  *J CROSSES ARE DISCOUNTED BY
                                            $.10 PER KG AT WEANING;
ADJWN2R=NCW2*WW2052*ADJWNPR;
ADJWN3R=NCW3*WW205*ADJWNPR;
ADJCALFR=ADJWN2R+ADJWN3R;
ADJCCR=CULLR+ADJCALFR; *TOTAL COW-CALF REVENUE WHEN J CROSS CALVES
                        ARE DISCOUNTED;
ADJPROFW=ADJCCR-ECOWCALF; *TOTAL PROFIT OF COW-SEGMENT WHEN J CROSS CALV
         ES ARE DISCOUNTED (ABOVE BASE LAND AND COW HERD COST);

*******************************************************;

*FEEDLOT PARAMETERS;

FPTDN=.7190;         *AVG TDN CONTENT OF FEEDLOT DIET;
FTDN=FI*DOF*FPTDN;   *KG TDN PER CALF IN FEEDLOT TO REACH CH- GRADE;
FTDNC=.1742;         *FEEDLOT RATION COST = $.1742 / KG TDN;
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*-----------------------------------------;
 *ALTERNATE COST OF FEEDLOT TDN;
  IF ALTTDNC=1 THEN DO;
     FTDNC=FTDNC*.75;  END;
  IF ALTTDNC=2 THEN DO;
     FTDNC=FTDNC*1.25; END;
*-----------------------------------------;

*FEEDLOT DEATH LOSS (UNPUBLISHED DATA);

 IF BG=1 THEN FLOSS=.014;
 IF BG=3 THEN FLOSS=.018;
 IF BG=4 THEN FLOSS=.004;
 IF BG=5 THEN FLOSS=.012;
 IF BG=6 THEN FLOSS=.031;
 IF BG=7 THEN FLOSS=.014;
 IF BG=8 THEN FLOSS=.020;

*FEEDLOT AND CUTABILITY DATA FOR CALVES FROM 2-YR-OLD COWS;

KG=2.2046;
IF BG=1 THEN DO; OTWT2=447/KG; DOF2=139; ADGTOT2=2.69/KG;
   FINWT2=815/KG; FE2=7.66;
   CARCWT2=496/KG; CUTAB2=46.8;
END;
IF BG=3 THEN DO; OTWT2=514/KG; DOF2=135; ADGTOT2=2.95/KG; FINWT2=891/KG;
   FE2=7.53; CARCWT2=542/KG; CUTAB2=47.6;
END;
IF BG=4 THEN DO; OTWT2=494/KG; DOF2=139; ADGTOT2=2.94/KG; FINWT2=885/KG;
   FE2=7.41; CARCWT2=545/KG; CUTAB2=47.0;
END;
IF BG=5 THEN DO; OTWT2=523/KG; DOF2=141; ADGTOT2=2.76/KG;
   FINWT2=900/KG; FE2=8.12; CARCWT2=551/KG; CUTAB2=47.4;
END;
IF BG=6 THEN DO; OTWT2=506/KG; DOF2=141; ADGTOT2=2.88/KG;
   FINWT2=899/KG; FE2=7.49; CARCWT2=552/KG; CUTAB2=47.5;
END;
IF BG=7 THEN DO; OTWT2=513/KG; DOF2=129; ADGTOT2=2.50/KG;
   FINWT2=818/KG; FE2=8.28; CARCWT2=495/KG; CUTAB2=47.9;
END;
IF BG=8 THEN DO; OTWT2=507/KG; DOF2=129; ADGTOT2=2.56/KG;
   FINWT2=828/KG; FE2=8.11; CARCWT2=491/KG; CUTAB2=47.5;
END;

  FTDN2=(FINWT2-WW2052)*FE2*FPTDN;

*-----------------------------------------;

NCF2=NCW2-(NCW2*FLOSS);  *NO. CALVES SOLD FROM FEEDLOT (2-YR-OLDS);
NCF3=NCW3-(NCW3*FLOSS);  *NO. CALVES SOLD FROM FEEDLOT (3-9 YR OLD);
*KG LIVE SLAUGHTER SOLD;
 SLWT2=NCF2*FINWT2;  *FROM 2-YR-OLD COWS;
 SLWT3=NCF3*FINWT;  *FROM 3-9 YR-OLD COWS;
 SLWT=SLWT2+SLWT3;   *TOTAL;
*KG CALF CARCASS WEIGHT SOLD;
 CWT2=NCF2*CARCWT2;   *FROM 2-YR-OLD COWS;
 CWT3=NCF3*CARCWT;    *FROM 3-9 YR-OLD COWS;
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 CWT=CWT2+CWT3;       *TOTAL;
*KG CALF RETAIL CUTS SOLD;
 RCWT2=NCF2*CARCWT2*CUTAB2/100;  *FROM 2-YR-OLD COWS;
 RCWT3=NCF3*CARCWT*CUTAB/100;   *FROM 3-9 YR-OLD COWS;
 RCWT=RCWT2+RCWT3;              *TOTAL;

*--------------------------------------------------------------;

FTDNTOT2=.5*(NCW2+NCF2)*FTDN2;  *ASSUMES THAT THE NO. OF CALVES
     CONSUMING TDN IS MIDWAY BETWEEN THE NO. OF CALVES SLAUGH-
     TERED AND THE NO. ENTERING THE FEEDLOT (THE DIFFERENCE IS
     DEATH LOSS).  FTDNTOT2 IS THE TOTAL BREED GROUP INTAKE
     FOR THE ENTIRE FEEDING PERIOD FOR CALVES FROM 2-YR-OLDS;

FTDNTOT3=.5*(NCW3+NCF3)*FTDN;  *SAME AS ABOVE, EXCEPT FOR
         CALVES OUT OF 3-9 YR-OLD COWS;

FTDNTOT=FTDNTOT2+FTDNTOT3; *TOTAL KG TDN FOR BREED GROUP IN FEEDLOT;

*-----------------------------------------------------------------;

*REVENUE FROM FEEDLOT SEGMENT;

 *BASED ON SLAUGHTER CALF LIVE WEIGHT;
 SLCALF2R=NCF2*FINWT2*SLCALFPR;  *CALVES FROM 2-YR-OLD COWS;
 SLCALF3R=NCF3*FINWT*SLCALFPR;   *CALVES FROM 3-9 YR-OLD COWS;
 FR=SLCALF2R+SLCALF3R;           *TOTAL REVENUE FROM FEEDLOT;

 *BASED ON SLAUGHTER CALF CARCASS WEIGHT;
 CW2R=NCF2*CARCWT2*CWPR;         *CALVES FROM 2-YR-OLD COWS;
 CW3R=NCF3*CARCWT*CWPR;          *CALVES FROM 3-9 YR-OLDS;
 CWR=CW2R+CW3R;                  *TOTAL CARCASS WEIGHT REVENUE;

 *BASED ON BONELESS, CLOSELY TRIMMED RETAIL CUTS OF CALVES;
 RCR2=NCF2*CARCWT2*CUTAB2*RCPR/100;
 RCR3=NCF3*CARCWT*CUTAB*RCPR/100;
 RCR=RCR2+RCR3;                  *TOTAL RETAIL CUTS REVENUE;
*-----------------------------------------------------------------;

*EXPENSES FROM FEEDLOT SEGMENT;

 ETDN=FTDNTOT*FTDNC;  *FEED EXPENSE FOR BREED GROUP;

   LOT=.05;  *LOT CHARGE = $.05 PER HEAD PER DAY;
   LOTPH2=LOT*(DOF2+21);  *LOT CHARGE PER HEAD FOR ENTIRE FEEDING
    PERIOD. 21 IS FOR THE PRE-FEEDLOT WARMUP PERIOD;
   LOTPH3=LOT*DOF;   *LOT CHARGE PER HEAD FOR ENTIRE FEEDING
                      PERIOD (3-9 YR-OLD HERD);

ELOT=(LOTPH2*NCW2)+(LOTPH3*NCW3); *TOTAL GROUP EXPENSE FOR LOT CHARGE;

VET=4.50;  *VET CHARGE PER HEAD;
SICK=1.00; *SICK PEN CHARGE PER HEAD;

EMED=(VET+SICK)*(NCW2+NCW3);  *TOTAL BREED GROUP MEDICAL EXPENSE;

MED2=(VET+SICK)*NCW2;  MED3=(VET+SICK)*NCW3;
*-------------------------------------------------------------------;
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*CALCULATION OF INTEREST CHARGES FOR FEEDLOT;

   *DAYS ON FEED FOR THE MONTHS IN WHICH DOF DIFFERS AMONG GROUPS;
    IF BG=1 THEN DO;
       DFEB=16; DMAY=31; DJUN=10; END;
    IF BG=3 THEN DO;
       DFEB=12; DMAY=31; DJUN=20; END;
    IF BG=4 THEN DO;
       DFEB=16; DMAY=31; DJUN=22; END;
    IF BG=5 THEN DO;
       DFEB=18; DMAY=31; DJUN=7; END;
    IF BG=6 THEN DO;
       DFEB=18; DMAY=31; DJUN=16; END;
    IF BG=7 THEN DO;
       DFEB=6;  DMAY=25; DJUN=0; END;
    IF BG=8 THEN DO;
       DFEB=6;  DMAY=31; DJUN=3; END;

 CFOCT1=FTDNTOT2*(31/DOF2)*FTDNC;  CFDEC1=CFOCT1;
 CFOCT2=FTDNTOT3*(31/DOF)*FTDNC;   CFDEC2=CFOCT2;
 CFOCT3=LOTPH2*NCW2*(31/DOF2);      CFDEC3=CFOCT3;
 CFOCT4=LOTPH3*NCW3*(31/DOF);      CFDEC4=CFOCT4;
 CFOCT5=MED2*(31/DOF2);            CFDEC5=CFOCT5;
 CFOCT6=MED3*(31/DOF);             CFDEC6=CFOCT6;
 SUMCFOCT=SUM(OF CFOCT1-CFOCT6);   SUMCFDEC=SUMCFOCT;

 CFNOV1=FTDNTOT2*(30/DOF2)*FTDNC;  CFJAN1=CFDEC1;
 CFNOV2=FTDNTOT3*(30/DOF)*FTDNC;   CFJAN2=CFDEC2;
 CFNOV3=LOTPH2*NCW2*(31/DOF2);     CFJAN3=CFDEC3;
 CFNOV4=LOTPH3*NCW3*(31/DOF);      CFJAN4=CFDEC4;
 CFNOV5=MED2*(31/DOF2);            CFJAN5=CFDEC5;
 CFNOV6=MED3*(31/DOF);             CFJAN6=CFDEC6;
 SUMCFNOV=SUM(OF CFNOV1-CFNOV6);   SUMCFJAN=SUMCFDEC;

 CFFEB1=FTDNTOT2*(DFEB/DOF2)*FTDNC;
 CFFEB2=FTDNTOT3*(28/DOF)*FTDNC;
 CFFEB3=LOTPH2*NCW2*(DFEB/DOF2);
 CFFEB4=LOTPH3*NCW3*(28/DOF);
 CFFEB5=MED2*(DFEB/DOF2);
 CFFEB6=MED3*(28/DOF);
 SUMFEB=SUM(OF CFFEB1-CFFEB6);
 SUMCFFEB=SUMFEB-SLCALF2R;  *NOTE SUBTRACTION OF REVENUE FROM SALE;

 CFMAR1=CFJAN2;
 CFMAR2=CFJAN4;  CFAPR1=CFNOV2; CFAPR2=CFNOV4; CFAPR3=CFNOV6;
 CFMAR3=CFJAN6;
 SUMCFMAR=SUM(OF CFMAR1-CFMAR3);
 SUMCFAPR=SUM(OF CFAPR1-CFAPR3);

 CFMAY1=FTDNTOT3*(DMAY/DOF)*FTDNC;
 CFMAY2=LOTPH3*NCW3*(DMAY/DOF);
 CFMAY3=MED3*(DMAY/DOF);
 SUMCFMAY=SUM(OF CFMAY1-CFMAY3);

 CFJUN1=FTDNTOT3*(DJUN/DOF)*FTDNC;
 CFJUN2=LOTPH3*NCW3*(DJUN/DOF);
 CFJUN3=MED3*(DJUN/DOF);
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 SUMCFJUN=SUM(OF CFJUN1-CFJUN3);

*THE FIRST STATEMENT IS THE AMOUNT ON WHICH INTEREST WILL BE
 PAID.  THE SECOND IS THE AMOUNT OF THE INTEREST;

 SF1=SUMCFOCT;       IF1=SF1*AI*(31/365);
 SF2=SF1+IF1+SUMCFNOV;  IF2=SF2*AI*(30/365);
 SF3=SF2+IF2+SUMCFDEC;   IF3=SF3*AI*(31/365);
 SF4=SF3+IF3+SUMCFJAN;   IF4=SF4*AI*(31/365);
 SF5=SF4+IF4+SUMCFFEB;  IF5=SF5*AI*(28/365);
 SF6=SF5+IF5+SUMCFMAR;  IF6=SF6*AI*(31/365);
 SF7=SF6+IF6+SUMCFAPR;  IF7=SF7*AI*(30/365);
 SF8=SF7+IF7+SUMCFMAY;  IF8=SF8*AI*(DMAY/365);
 SF9=SF8+IF8+SUMCFJUN;  IF9=SF9*AI*(DJUN/365);

EFI=SUM(OF IF1-IF9);  *TOTAL INTEREST ON FEEDLOT COSTS;


  HAUL=12.00;  *HAULING EXPENSE = $12 PER HEAD;
  SC=1.25;     *SALES COMMISSION = $1.25 PER HEAD;

EMARKET=(HAUL+SC)*(NCF2+NCF3);  *TOTAL BREED GROUP MARKETING EXPENSE;

EFDLT=ETDN+ELOT+EMED+EMARKET+EFI; *TOTAL FEEDLOT EXPENSE;

   EFDLTOP=EFDLT-ETDN; *TOTAL NON-FEED COSTS FOR FEEDLOT;
******************************************************************;

*PROFIT EQUATIONS FOR SELLING CALVES AT SLAUGHTER;

 PROFLW=FR+CULLR-EFDLT-ECOWCALF;  *BREED GROUP PROFIT (ABOVE BASE COW
                HERD) SELLING OF A LIVE WEIGHT BASIS;
 PROFCW=CWR+CULLR-EFDLT-ECOWCALF; *SELLING ON CARCASS WEIGHT BASIS;
 PROFRC=RCR+CULLR-EFDLT-ECOWCALF; *SELLING ON RETAIL CUTS BASIS;

   *TOTAL REVENUE WHEN CALVES ARE SOLD AT SLAUGHTER;
       RTOTLW=FR+CULLR;
       RTOTCW=CWR+CULLR;
       RTOTRC=RCR+CULLR;
     *TOTAL EXPENSES WHEN CALVES ARE SOLD AT SLAUGHTER;
       ETOTSL=EFDLT+ECOWCALF;

******************************************************************;

DROP BIRWT BTWNADG COWEFF MEFFKG FINAGE NLPD LPD TOTPD ADJPD ;

CARDS;
PROC PRINT;
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VITA

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Donald Monroe Marshall

Candidate for the Degree of

Doctor of Philosophy

Thesis: PRODUCTIVITY AND ECONOMIC COMPARISONS AMONG TWO-BREED CROSS COW GROUPS PRODUCING THREE-BREED CROSS CALVES

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