PRODUCTIVITY OF TWO-YEAR-OLD CROSSBRED COWS

PRODUCING THREE-BREED CROSS CALVES

By

CARLA GALE ~~BELCHER~~ Chenette

Bachelor of Science

University of Connecticut

Storrs, Connecticut

1977

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
December, 1978

PRODUCTIVITY OF TWO-YEAR-OLD CROSSBRED COWS

PRODUCING THREE-BREED CROSS CALVES

Thesis Approved:

Richard R Frahm
Thesis Adviser

Keith Lusby

Milton Wells

Norman N Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

I wish to express a special thank you to Dr. R. R. Frahm, Professor of Animal Science, who has served as major adviser for my M.S. program. His constant encouragement, counsel and guidance in my graduate program and thesis preparation are deeply appreciated.

I also wish to acknowledge the unending assistance of my husband, Danny, in not only the collection and compiling of data, but also his patience, constant love and understanding of having a wife in graduate school.

Special appreciation is also extended to Dr. R. W. McNew, Associate Professor of Statistics, for his help in solving the statistical problems involved in the analysis of my thesis data. I am also grateful to Dr. K. S. Lusby, Assistant Professor of Animal Science and Dr. M. E. Wells, Professor of Animal Science, for their critical evaluation and helpful suggestions while serving on my M.S. Committee.

A very special thanks is extended to Mr. Ed Bennett, the project herdsman, and his wife, Ann, for their friendship, unending help and understanding of research.

I also wish to express my deep love to my parents, Jim and Anne Chenette and my sisters, Yvonne and Gigi, for their constant encouragement that has gotten me this far in my career.

TABLE OF CONTENTS

LIST OF TABLES

Table		Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Research studies have shown tremendous advantages of crossbreeding in terms of increased productivity of crossbred dams and crossbred calves. Systematic crossbreeding in commercial beef herds has become increasingly important during the past two decades as producers have been forced to strive for efficiency of production. The advantages of crossbreeding can be realized by 1) increased performance due to heterosis and 2) by combining the desired characteristics of two or more breeds.

Since heterosis is greatest for traits of low to moderate heritabilities, its primary benefits are to be expected in fertility and mothering ability of the crossbred cow and preweaning traits of the crossbred calf. Also realized are advantages in postweaning growth and carcass merit due to heterosis. Cundiff (1970) summarized many crossbreeding experiments dealing with beef cattle. When using British breeds in systematic crossbreeding, production per cow exposed can be increased up to 25 percent. There may be an even greater advantage as the breeds incorporated into the crossbreeding scheme have more genetic diversity. The majority of this production gain is due to the use of crossbred dams. Through crossbred dams, the heterosis benefits for reproductive traits and mothering ability are realized. Hereford and Angus have been the most commonly used breeds for crossbreeding studies in the United States due to their numerical prominence although some studies have involved Charolais, Brahman and other beef breeds of non-British origin. The heterosis realized from crossbreeding is of larger magnitude with British x Brahman crosses than British x British.

The advantages of crossbreeding are now evident, although the question still remains as to which breeds to involve in crossbreeding schemes to maximize production efficiency under a particular management system. It is important to determine which breeds will best combine and excel as commercial cows, which will make the best contributions as sires in terminal cross systems and also to determine which breeds are most complimentary for a rotational crossbreeding system. Currently, there are extensive studies underway to evaluate various breed combinations in the United States and other countries.

The objectives of this study were to 1) compare the productivity of various two-breed cross heifer groups when managed to produce their first calf at two-years of age, and 2) to compare milk yields and butterfat content of the milk produced during their first lactation. The study is a portion of an extensive research program at the Oklahoma Agricultural Experiment Station comparing the lifetime productivity of various two-breed cross cows mated to bulls of a third breed.

CHAPTER II

REVIEW OF LITERATURE

This review of literature is divided into sections that deal with 1) factors contributing to increased productivity of crossbred cattle, 2) production results of various types of crossbred dams, and 3) estimates of beef cattle milk production and composition.

Factors Contributing to Increased Productivity of Crossbred Cattle

Cundiff (1970) in an excellent review of beef crossbreeding studies reported many advantages of crossbred dams and crossbred calves to increase beef cattle production. Two-breed cross cows of the Angus, Hereford and Shorthorn breeds showed a significant advantage in percent calf crop raised and calf weaning weights when mated to a third sire-breed. Pounds of calf weaned per cow exposed in the breeding herd was increased 20 to 25% from a three-breed cross system as compared to a straight breeding system. Crossbred calves showed advantages in calf survival, percent calf crop weaned and weaning weights over straightbred calves.

In a study involving Hereford, Angus and Shorthorn Cattle, all producing crossbred calves, Cundiff et al. (1974) reported a 6.4% increase in calf crop weaned for crossbreds over straightbreds due to a significantly higher pregnancy rate in the crossbreds. Differences in postnatal survival of calves were small and non-significant, while weaning weight per cow exposed gave a 14.8% advantage of the crossbreds with the cumulative effect of individual and maternal heterosis of a 23% advantage of pounds of calf weaned per cow exposed. It was also reported that Angus x Hereford cows had a significant advantage over Hereford x Angus cows for percent live calves weaned (+11.1 ± 5.3%) and for 200 day weaning weight divided by cow weight (+34 ± 11).

Cundiff et al. (1974) reported crossbred Hereford, Angus and Shorthorn dams had a 1.7%, 4.7% and one-sixth of a grade advantage in maternal heterosis for birth weight, weight at 200 days of age and weaning conformation grade, respectively. It was observed that crossbred cows had a greater and more persistent milk production throughout lactation than straightbreds and also had higher butterfat content.

Another aspect of cow efficiency is related to cow weight and cow size. Gregory et al. (1950) reported that cows with the smallest gains during the nursing period tended to produce calves making the largest gains from birth to weaning. Cows tended to repeat their previous performance for gain of their calves from birth to weaning and calf weaning weight to a higher degree than for birth weight.

In an experiment involving Hereford cows, Singh et al. (1970) reported that the influence of a dam's weight on her calf's birth weight was highly significant, but that cow weight had no significant effect on preweaning average daily gain or weaning weight. He also found heavier cows tended to wean heavier calves. They observed that cow weight changes during the suckling period influenced preweaning average daily gain and weaning weight and reported that for each one percent loss in cow weight during her lactation added .31 to 2.40 pounds to her calf's weaning weight.

Kress et al. (1969) reported data from 56 identical and fraternal twin beef cows and observed estimates of efficiency were negatively related to cow weight at calving and positively but seldom significantly related to cow height at the withers. Therefore, they hypothesized that fatter cows are less efficient producers of calves and that skeletally large and small cows are approximately equal in efficiency.

Klosterman (1972) in a review article on beef cattle size reported many studies showing a negative relationship between cow weight and efficiency (e.g., Wilson and Lindsey, 1970; Hauser and Chapman, 1969). He stated that weight alone was not a good measure of cow size and that small cows are not always the most efficient in a total beef production scheme. Small cows do, however, have an advantage for stocking rate over larger cows and lower maintenance costs, but this may be offset by a lower salvage value for a small cow. Klosterman added that reproductive performance is more closely related to efficiency than any other variable including cow size.

Dinkel and Brown (1978) reported on accuracies of indicators of cow efficiency. The study evaluated 122 records of calf weaning weights and ratios of calf weights to cow weights or metabolic body size to determine which was the single best predictor of efficiency. Their results indicated that the amount of feed required for a cow to produce a pound of calf at weaning was explained by the calf's weaning weight with a R^2 value of 81 percent. The ratio of calf weaning weight to cow metabolic weight explained efficiency with 79 percent accuracy while the ratio of calf weight to cow weight had an accuracy of 73 percent. They concluded the ratios tended to be biased in favor of the small cow.

Production Results of Various Types of Crossbred Dams

A study is currently in progress at the U.S. Meat Animal Research Center (USMARC) to characterize various breeds for growth, efficiency, reproduction, maternal ability, feedlot and carcass traits. Phase 2 of Cycle I of the study involves various two-breed cross heifers mated to produce three-breed cross calves. Heifers of interest included Angus x Hereford (AH), Hereford x Angus (HA), Jersey x Hereford (JH), Jersey x Angus (JA), Simmental x Hereford (SH), and Simmental x Angus (SA), that were mated to Hereford, Angus, Devon and Holstein bulls to produce their first calf at two years of age. Laster et al. (1976) reported data involving 177 Jersey cross, 157 Simmental cross and 132 HA reciprocal cross heifers. During the cows' first breeding season about 86% of the Simmental and Jersey cross heifers and 93% of the AH and HA heifers conceived.

In USMARC Progress Report No. 2 (1975) it was reported that cow weights as two-year-olds ranged from the SH at 958 pounds to the JA at 791 pounds. Pregnancy percentages varied from AH at 96.2% to JA at 79.0% with an overall average of 85.4% live calves born and 77.9% calf crop weaned. Calf birth weights were heaviest for the Simmental crosses (76.0 lb) and lightest for the Jersey crosses (65.4 lb). The most calving difficulty was experienced by the Simmental crosses (46.1%). Jersey crosses had the best rebreeding performance (93.7%) as two-year-olds.

Notter et al. (1978) reported on this group of cattle as two and three-year-olds. As two-year-olds, Jersey and Simmental cross cows had the heaviest calves at 200 days (399 lb) and HA reciprocal cross cows had the lightest calves (362 lb).

Cycle II of the USMARC Program added more cows including 116 Brown Swiss cross and an additional 61 HA reciprocal cross cows. As reported in USMARC Progress Report No. 5 (1977) Brown Swiss crosses had a higher percent calf crop born (92.2 vs 82.6%) and weaned (75.9 vs 69.4%), less calving difficulty (35.9 vs 54.15), higher birth weights (81.2 vs 75.4 lb) and a higher rebreeding percentage (93.4 vs 90.2%) than HA reciprocal cross cows. The cow groups were not significantly different in weight as two-year olds.

In a cooperative study between USMARC and a research station in Lethbridge, Alberta, Canada, 25 HA, 25 JA, 29 SA and 28 Charolais x Angus (CA) heifers were shipped to Canada for evaluation as two-year-olds when mated to Red Poll bulls. Browden et al. (1977) reported that calves born to JA heifers were significantly lighter than calves from the other heifer types. The HA and JA cows were lighter at their first calving than SA or CA crosses. The JA and CA cows had the least calving difficulty at 34 percent of over 1,000 crossbred cows.

Another extensive program at Brandon, Manitoba, Canada involving Charolais, Limousin and Simmental in all combinations with Angus, Hereford and Shorthorn as well as a Hereford x Angus reciprocal cross control group. All heifers were bred to Beefmaster or Red Angus bulls. Freeden et al. (1974) reported data on heifers born in 1971 and 1972. The breeds of interest are Simmental x Hereford (SH), Simmental x Angus (SA) and the Hereford x Angus (HA) reciprocal crosses. Overall 84.2% of the heifers conceived with the SH, SA and HA cross cows at 85.1, 82.2 and 86.5%, respectively. The three crosses were similar in percent calving difficulty (26.7%). The Simmental crosses were heavier in weight at their first calving (+93 lb) and had calves with heavier birth weights and weaning weights (+52 lb) than HA cross cows. For measures of cow productivity, SA and HA were similar in percent calf weaned (80.3%) and SH were lower (74.4%). In terms of pounds of calves weaned per cow exposed, SA were most productive (334 lb) followed by SH at 315 lb and HA at 297 pounds. The three crosses were similar in ratio of calf weaning weight to weight of the cow at calving.

Several studies have involved Angus, Hereford and Charolais crossbreeding systems as Charolais was one of the first exotic breeds imported to the United States. Sagebiel et al. (1969) reported on calving difficulty involving purebred Angus, Hereford and Charolais heifers and all possible two-breed combinations among the three breeds. The project involved 529 calves produced by these heifers. Most difficulty in calving was experienced by HA, CA and CH heifers (averaged 26.7%) and AC heifers had the least dystocia (0.0%). The amount of calving difficulty for male calves was not significantly different for the purebred versus the crossbreds, however, crossbred cows producing female calves had more dystocia than purebred cows. The correlation coefficient between dystocia score and post-calving cow weight were low, negative and generally nonsignificant, while correlation coefficient between dystocia and ratio of calf birthweight to cow weight indicated that the larger the calf in relation to the cow, the more dystocia experienced.

Marshall et al. (1976) reported on factors affecting efficiency in 73 Angus, Charolais and reciprocal cross cows producing calves from a polled Hereford bull. They concluded that cow weight did not significantly affect efficiency, so larger cows apparently produce enough more calf weight to balance their greater nutrient requirements. Milk production accounted for 23% of the variation in cow efficiency and weaning weight of her calf accounted for 62% of the variation.

In a large crossbreeding study in Louisiana involving six years of data, Turner and McDonald (1969) summarized records of 1270 calves produced from Angus, Brangus, Brahman and Hereford and 16 crossbred cow groups mated to Angus, Brangus, Brahman, Hereford and Charolais bulls in all possible combinations. In general, they found that three-breed cross calves were superior for all traits when compared to straightbred, single cross and backcross calves.

Recently, interest has developed in beef x dairy crossbred cows to increase milk production of the dam and growth rate of her calves. Beef x dairy cross cows are expected to produce more milk, but also of interest are other economically important cow and calf traits. Productivity of two-year old Angus x Holstein cross cows compared to Angus cows under range conditions was studied by Deutscher and Whiteman (1971). There were 31 crossbred and 41 Angus cows in the study. The average birth weight of the backcross calves was significantly heavier than Angus (67.0 vs 51.8 lb) and the difference increased at weaning (425.5 vs 365.1 lb) while their average conformation and condition scores were similar at weaning. The crossbred cows were significantly heavier and lower in condition than the Angus cows in both spring and fall. The two groups were similar in conception rate (85%) and in percent live calves born (85.7%) for their first calf crop but the Angus x Holstein cows that nursed calves had a significantly lower rebreeding percentage. Only three out of 23 (13%) rebred lower while 17 out of 27 (63%) of the lactating Angus cows rebred.

In another study by Holzgraefe et al. (1976) data involving 240 head of Hereford (H), Angus x Hereford (AH), Jersey x Hereford (JH) and Red Fresian x Hereford (FH) cows were reported. As two-year olds, all were bred to Angus bulls and their second and third calves were sired by Red Poll bulls. The dairy crosses weaned heavier calves (423 lb) than the AH (353 lb) or the Hereford cows (295 lb). Dairy crosses also weaned more pounds of calf per 100 cows exposed in the breeding pastures due to higher calf weaning weights and more calves weaned.

Baker and Carter (1976) reported on a study involving 126 Hereford x Angus (HA), 118 Fresian x Angus (FA), 83 South Devon x Angus (DA), and 50 Charolais x Angus (CA) cross cows in New Zealand. Although all breed groups were similar in percent calving (89.0%) and percent calves weaned (78.5%), FA cows weaned the heaviest calves (395 lb) by 45 pounds. The FA group was also most productive in terms of weight of calf weaned per cow mated (324 vs 270 lb) and most efficient (productivity per 220 lb of cow live weight.)

A comparison of calves from Angus x Hereford (AH), Holstein x Angus (HoA), and Holstein x Hereford (HoH) cows was made by Baharin and Beiharz (1975). The average birth weight of the 38 AH calves was 67.7 lb and was significantly lighter than the 40 Holstein cross calves (average 76.3 lb). Average daily gain to weaning of the three types of female calves was not significantly different (1.68, 1.86, 1.85 lb/day for AH, HoA, HoH, respectively), however the male Holstein cross calves gained more rapidly than the AH cross calves (2.07 vs 1.80 lb/day.)

Parker (1975) reported on first calf performance of 22 Angus, 21 Charolais, 33 Angus x Charolais reciprocal crosses (AC), 12 Jersey x Angus (JA), 18 Jersey x Charolais (JC), 18 Brown Swiss x Angus (BA) and

20 Brown Swiss x Charolais (BC) cross cows when mated to Hereford bulls. The percentage of cows calving varied from JA at 100.0% to the BA at 66.2 percent. The BC cows gave birth to the heaviest calves (75.6 lb) and the lightest calves were from the JA and Angus cows (63.1 lb). The JA cows had the poorest livability of their calves (70.6%) but weaned the heaviest calves (431.6 lb). Calves from AC cross dams were lightest at weaning (342.3 lb). Overall, the dairy cross cows weaned calves heavier than the straightbred or crossbred beef cows by 62.2 lb (average 415.4 vs 352.8 lb, respectively).

Estimates of Beef Cattle Milk Production and Composition

Milk production or maternal performance is of great importance to beef production as it interacts with many beef traits. Willham (1972) pointed out in an excellent review article that increased milk production of beef herds is desirable and advantageous from the efficiency point of view, especially when considering the possible use by the cow of low quality forage, which is not utilized by the calf. The importance of milk production is directly reflected by the weaning weight of beef calves. Neville (1962) reported that 66% of the variation in calf weight at eight months of age is due to milk consumption and that the importance was most significantly reflected early in the calf's life (60 to 90 days).

Drewey, Brown and Honea (1959) found 60% of the variation in weight at six months due to milk consumption and Pope et al. (1963) agreed, finding 50% of variation in average daily gain from birth to weaning could be explained by milk production differences of their dams. Jeffery and Berg (1971) reported milk yield of the dam accounted for 60% of the variation in preweaning average daily gain and 40 to 50% of the variation in weaning weight.

Franke et al. (1975) found a correlation of milk yield and average daily gain from birth to seven months as .45 for Angus cows and .41 for Hereford cows. Totusek et al. (1973) reported a .88 correlation between milk yield and 210 day calf weight.

Milk production was also found to affect cow efficiency by Marshall, Parker and Denkel (1976) in a study involving 73 cows over a three-year period. They reported milk production alone accounted for 23% of the variation in efficiency to weaning of Angus, Charolais and recriprocal cross cows. The efficiency was measured in drylot and was calculated as the ratio to total TDN intake of the cow and calf to weaning weight of the calf.

Gifford (1949) reported that maximum milk production normally obtained during the first six weeks of lactation was affected by the capacity of young calves to consume milk. If milk was not removed from the udder, production from high producing cows seemed to level off at 12 to 15 lb daily before the normal decline.

The problem of what methods to use for estimating milk yields in beef cattle has been a major one. Many techniques have been employed from estimates by differences in calf weights before and after suckling (Neville, 1962; Brown and Honea, 1959; Melton, 1967; and others) to teat cannulation (Lamond et al., 1969) to hand or machine milkout of the udder or a portion of it (Jeffery et al., 1971; Gleddie et al., 1968; Gifford, 1953; and others.) In Lamond's study (1969), it was shown that time of day of the test did not effect yield of milk and that oxytocin did not influence the rate of milk secretion.

The use of oxytocin before or after suckling and before machine milkout was researched by Schwulst et al. (1966). Twenty-four Angus cows were involved in three treatments; 1) control; 2) oxytocin after nursing and prior to machine milking; and 3) oxytocin before both. The calf nursing method was used with machine milkout following to obtain milk left by the calf after suckling. Oxytocin had no significant effect on milk consumption by the calf or total milk production. Many workers have used intramuscular or intraveinous injections of oxytocin before machine milkout in beef cattle (Wistrand and Riggs, 1966; Wilton, 1973; Cobb et al. 1978; Jeffery et al. 1971; and others).

Milk production estimates have been obtained by both calf nursing and milkout techniques by several researchers. Wistrand and Riggs (1966) in a study involving 26 lactations of Sanita Gertrudes cows found no significant difference between the two methods. Twenty-four hour production ranged from 12.3 to 17.4 lb of milk per cow over a 205 day lactation. Calf nursing estimates (4.9 lb/day) were higher than machine milkout estimates (3.5 lb/day) in a study reported by Wilton (1973). Milk yield was measured on 15 beef cows one time per month for six months involving both methods. The correlation was estimated as .42 between the two techniques.

Totusek and Arnett (1965) also found higher estimates for calf nursing (12.9 lb/day) than hand milking (10.0 lb/day) when studying 24 beef cows in drylot during three lactations. Correlations between the two methods ranged from .84 to .95 at various times during the lactation. In another publication by Totusek et al. (1973), 36 complete 210 day lactations of beef cows in drylot were studied. Calves were separated from their dams at ten days of age and then allowed to nurse twice daily until they were weaned at an average age of 210 days. Six days per week, calf nursing estimates of milk yield were recorded and one day per week an udder half was handmilked while the calf nursed the other half in the morning and a reverse was done that evening. Calf nursing estimates were higher than handmilking (12.9 vs 10.0 lb/day) suggesting that handmilking tended to underestimate milk consumed by the calf. Estimates based on two days during mid and late lactation had a .87 correlation with 210 day yield while estimates based on four days (day 30, 70, 112 and 210) increased the correlation (r = .91). Butterfat averaged 3.2% and 67.9 total pounds.

Gleddie and Berg (1968) measured milk yields by both machine milkout following an oxytocin injection and calf nursing on a variety of 42 purebred and crossbred cows. A .58 correlation was estimated between the two methods. Machine milkout estimates ranged from 8.2 to 18.5 lb/day while calf nursing was similar at 8.4 to 7.2 pounds per day. Butterfat averaged 3.9 percent.

Belcher et al. (1978) reported machine milkout preceeded by an oxytocin injection estimated higher milk yields by 5% in 40 Hereford and Angus cows than calf nursing and by 64% in 64 crossbred cows.

Few heterosis estimates for milk production in beef cows are available in literature. Schwulst et al. (1978), reporting on 149 crossbred and 101 straightbred cows and calves of Angus, Hereford and Shorthorn breeding, estimated heterosis values of 1.6%, 8.5%, 6.8% and 3.8% for milk at two weeks, six weeks, June and weaning observations, respectively. Crossbred cows produced 6.8, 7.6, 7.9 and 3.3 lb of milk per day for the respective observations. Corresponding observations for straightbred cows were 6.7, 7.0, 7.4 and 2.4 pounds per day.

Jeffrey et al. (1971), studying milk yields of cows and preweaning performance of their calves, found a 2.2 lb increase in daily milk yield resulting in 24 to 31 additional pounds of calf weaned. This study involved 377 cows of Angus, Hereford, Galloway, Hybrid and Hereford x Hybrid crosses. Milk yields and composition samples were obtained by a machine milkout after an oxytocin injection six hours after cow and calf were separated. Estimates were obtained over two periods in August and October during mid and late lactation.

The mean 24 hour milk yields ranged from 8.4 to 13.4 lb and butterfat ranged from 4.10 to 5.77 percent. In looking at factors influencing milk yield, they found breed and age of dam differences accounted for 82% and 87% of the variation, respectively. By holding cow age constant, post calving weight explained 0.0 to 8.5% additional variance in milk yield, agreeing with Pope et al. (1963) who found body size of the dam had little bearing on her milk production. They also found summer weight gain had a negative association with milk yield and winter weight loss had little influence. The effects of calf sex were inconsistent on milk yield and birth weight of the calf had a small positive influence.

Estimates of milk yield and composition are varied in the literature. Cole and Johansson (1933) recorded milk yield and composition on seven Angus cows that were milked every day. Their average production was 10.0 lb/day for a 321 day lactation at 4.41% butterfat. Drewry, Brown and Honea (1959) reported estimates for milk yield on 48 Angus cows as 14.1, 16.0 and 9.0 lb/day for March, May and September, respectively. The estimates were obtained by the calf nursing method.

Gifford (1953) with handmilking one day per month, reported on the lactations of 28 Hereford, 7 Angus and 5 Shorthorn cows of various ages. Overall, the cows averaged 7.3 lb/day at 3.08% butterfat. He observed maximum milk and butterfat production on the average occurred during the first month of lactation and that high producing cows weaned the heaviest calves.

A milk yield estimates on 33 Hereford cows was obtained by Furr and Nelson (1962) by the calf nursing method. Overall, the cows averaged 6.16 lb of milk per day from seven monthly estimates. Other milk yield estimates on purebred cattle were made by Melton et al. (1967) by the calf nursing method. Following an oxytocin injection, one udder quarter was milked out to obtain composition estimates. In this study, 15 Angus, 15 Hereford and 15 Charolais cows averaged 7.1, 6.2 and 8.4 lb/day and 2.68, 2.82 and 2.87% butterfat, respectively.

Marshall et al. (1976) also reporting on Angus and Charolais cattle, found the cows produced 11.4 and 9.9 lb of milk per day, respectively, while the reciprocal crosses averaged 10.9 lb/day. A total of 73 cows were involved in this study and estimates were obtained by calf nursing.

Estimates involving dairy x beef cross cattle in the literature are higher than those observed for purebred and crossbred beef cows. McGinty and Frerichs (1971) estimated milk yield of 12 Brown Swiss x Hereford cows as 19.0, 13.2 and 11.5 lb/day at days 85, 135 and 180 of lactation respectively, while 12 Herefords in the same study yielded 8.8, 9.0 and 7.3 lb/day for corresponding observations.

A study involving 24 Angus x Holstein cross cows was reported by Wilson et al. (1969). Calf nursing techniques followed by a machine removal of milk remaining after suckling was used to obtain estimates.

Twenty-four hour estimates averaged 20.7 lb at 3.4% butterfat. Deutscher and Whiteman (1971), also studying Angus x Holstein cows, estimated milk production of 31 cows at 12.6 lb/day under range condition by the calf nursing method. Forty-one Angus cows in the same study averaged 8.8 pounds per day.

With two consecutive twelve hour separation calf nursings three times during lactation, Notter et al. (1978) estimated milk yield on 59 two year old crossbred dams as a portion of USMARC breed evaluation study. Overall, Jersey and Simmental crosses produced the most milk. Crossbreds of interest included 2 Jersey x Hereford, 8 Jersey x Angus, 5 Simmental x Hereford, 5 Simmental x Angus, 5 Hereford x Angus and 5 Angus x Hereford which produced 10.4, 12.6, 9.7, 11.0, 9.3 and 10.1 pounds of milk, respectively.

Estimates for these crossbreds were higher by Cobb, Frahm and Boyd (1978) who studied lactations of 64 Hereford x Angus reciprocal cross, Simmental cross, Brown Swiss cross and Jersey cross cows. Their estimates were obtained by machine milkout preceeded by an oxytocin injection. Estimates were taken once per month throughout the lactation. Average daily milk production of the Simmental, Brown Swiss and Jersey cross cows were 11.9, 12.6 and 12.8 lb, respectively at 4.1, 3.6 and 3.7% butterfat. Hereford x Angus reciprocal cross cows were lower in yield at 10.4 lb/day and their butterfat averaged 3.6 percent.

Summary Review of Literature

Available data suggest advantages of crossbred cows and calves over straightbreds are large, especially for reproductive, maternal and preweaning traits. This advantage is due to increased heterosis of traits with low to moderate heritabilities. Crossbreds have a high reproductive rate and grow faster to weaning than purebreds. Much of the increase in productivity of crossbred herds is due to the use of crossbred dams.

Other factors effecting cow efficiency relate to cow size and weight. The literature suggests that cows making the smallest weight gains during lactation are most efficient and the skeletally large cows of average to low condition along with small cows are more efficient producers than fat cows.

Breed contributions to crossbred operations are varied. Simmental crosses appear to increase birth weight, calving difficulty and cow weight. They tend to wean very desirable heavy calves. Jersey crosses, on the other hand, lower birth weights and calving difficulty as well as cow weight while weaning heavy calves and maintaining high fertility.

Beef x dairy crosses, with higher milk yields than beef cows, increase calf weaning weights and preweaning growth. However, poor rebreeding performance of heavy milking cows could be a problem. The data suggests much of the variation in preweaning average daily gain and weaning weight is explained by differences in cow milk production. Summer weight gains appear to be negatively associated with milk production. Milk and butterfat production appear to be maximum early in lactation and decline to weaning.

Methods of estimating beef cattle milk yields have varied in the literature. The most popular techniques are a difference in calf weights before and after suckling and a machine milkout preceeded by an oxytocin injection. The arguments follow that calf nursing measures calf consumption and not necessarily milk yield while machine milkout removes residual milk not available to the calf, but does allow for composition estimates.

Estimates of daily milk production are from 2 to 12 lb/day for purebred beef cattle with butterfat ranging from 2.7 to 4.5 percent. There appears to be some heterosis for milk production and butterfat content as crossbred beef cattle estimates vary from 3 to 14 lb/day milk yield and 3.2 to 5.8 percent butterfat. Dairy x beef crosses increase milk yields further, 9 to 20 lb/day, with butterfat from 3 to 4 percent in the literature.

CHAPTER III

MATERIALS AND METHODS

The Cow Herd

The data used in this study were the productivity traits measured on 440 crossbred range cows from first breeding through the weaning of their first calf. The crossbred heifers were produced by mating Angus (A) and Hereford (H) cows to Angus, Hereford, Simmental (S), Brown Swiss (B), and Jersey (J) bulls in 1972, 1973 and 1974 to produce eight crossbred groups (HA, AH, SA, SH, BA, BH, JA and JH). The Angus and Hereford cows represented a sample of good commercial range cows from Oklahoma. The Angus and Hereford bulls were selected from an Oklahoma Agriculture Experiment Station selection study, and the Simmental bulls from an artificial insemination organization. The Brown Swiss and Jersey bulls were from purebred breeders in the region and artificial insemination studs. A total of 12 bulls of each sire breed were used over the three year period, four different bulls of each breed each year. Most matings were by natural service, however, all 12 of the Simmental bulls, six Brown Swiss and four Jersey bulls were used by artificial insemination.

The heifers were born at the Lake Carl Blackwell Research Range from January through April of 1973, 1974 and 1975. Calves remained with their dams on native range until weaning in September at an average age of 205 days. Performance of these calves to weaning has been previously reported by Frahm, Boyd and Sharp (1976). All heifer calves produced by these matings were kept in the herd for evaluation as cows.

After weaning, all heifer calves were trucked to the Southwestern Livestock and Forage Research Station, at El Reno, Oklahoma, and grazed on wheat pasture through the winter. It must be noted here that wheat pasture from weaning to yearling for the cows born in 1973 was sparce and very poor quality due to insufficient rainfall. Their average daily gains were often very low and sometimes negative over this period. The cows born in 1974 and 1975 benefited from more normal conditions with regard to quality and quantity of wheat pasture available for grazing. Approximately one month before breeding the heifers were returned to the Lake Carl Blackwell Research Range and grazed on native grass. The heifers received 2 lb/head/day of 30% cottonseed meal and 6 lb/head/day of rolled corn as supplement through the breeding season. The heifers vaccination schedule is listed in Appendix Table XXIII.

A total of 440 two-breed cross heifers entered the cow herd. Table I shows the number of heifers in each crossbred group. All heifers were weighed and evaluated for condition before entering the breeding pastures. The condition scores range on a scale from 1 = very thin to 9 = extremely fat, with 5 being average fat cows.

A random half of the heifers in each crossbred group were mated to Red Poll bulls and the other half to Shorthorn bulls to produce their first calf at two years of age in the spring of 1975, 1976 or 1977. Red Poll and Shorthorn bulls were used in order to minimize calving difficulty normally associated with two-year-old cows. Three bulls of each sire breed were used each year and all matings were by natural service. The breeding season was from April 15 to July 1 each year.

TABLE I

NUMBER OF HEIFERS ENTERING THE COW HERD FOR EACH CROSSBRED GROUP

Crossbred[a]	Year First Calf Born 1975	1976	1977	Crossbred Group Totals
HA	21	15	11	47
AH	22	21	14	57
SA	23	27	21	71
SH	17	11	19	47
BA	16	17	14	47
BH	20	18	15	53
JA	25	18	16	59
JH	19	24	16	59
Age Group Totals	163	151	126	440

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

Each cow was pregnancy checked by rectal palpation the October following her first breeding. Four cows were culled at this time. Two were culled because they were extremely small, one had an abnormal reproductive tract and the other was considered wild and dangerous.

Through the winter the cows received 1 lb/head/day of 41% cottonseed meal cubes starting in November. Supplementation was raised to 2 lb/head/day around the first of December. Hay was also supplied, usually from the middle of December through calving. Approximately 7 to 10 days prior to calving the cows were moved into the calving lot and were fed 2 lb/head/day of 41% cottonseed meal cubes and free choice hay until they were moved back on pasture with their calf. After calving the cow's supplement was increased to 5 lb/head/day of 20% cottonseed meal cubes.

The cows started calving in January. Each cow was individually observed by the herdsman during the birth of her calf and given a calving score. Table II presents a description of those difficulty scores. Each calf was tatooed, eartagged and weighed within 24 hours of birth. Calf number, dam number, calf birthdate, sex of calf, calf birth weight and calving difficulty score were recorded. A total of five cows died during their first calving season.

All cows were weighed and evaluated for condition in the spring after calving and prior to entering the breeding pastures. The cows' second breeding season was May 1 to July 15 in 1975, 1976 or 1977. All calves remained with their dams on native range until weaning at the end of August at an average age of 205 days.

At weaning, all calves were weighed and given conformation and condition scores by a panel of at least three persons. The conforma-

TABLE II

CALVING DIFFICULTY SCORES[a]

Calving Difficulty Score	Description
1	No Difficulty: Calves unassisted; however it may be necessary to straighten head and/or front legs.
2	Little Difficulty: Assistance given by hand, but no jack or puller used; assistance actually may not have been required.
3	Moderate Difficulty: Assistance given with jack or calf puller; some difficulty encountered even with puller being used.
4	Major Difficulty: Calf jack used and major difficulty encountered; usually 30 minutes or more required to deliver calf.
5	Caesarean birth.

[a]The herdsman also entered any other notes about the birth in the calving record book.

tion scores were based on 13 = average choice for muscling and the condition scores were the same as used for the cows (5 = average fat cover). All cows were also weighed after their first weaning and given a body condition score. After weaning, all cows were pregnancy checked, any cows open for their first and second breeding seasons were culled. There were three culled for being open two years in a row. One cow was culled because of a small pelvic area and another because she was crippled by an enlarged hock.

Actual rebreeding performance data was calculated from the calving records of the cow's second calving the following spring. A cow was judged open if she failed to calve.

Milk Production and Composition Procedures

The milk producing abilities of a range cow and the composition of her milk are both important factors contributing to the overall productivity and efficiency of a beef cow. The data used in this portion of the study were collected from 56 two-year-old crossbred cows during their first lactation in the summer of 1977. These cows were selected at random from the cows born in 1975. Eight cows from seven crossbred groups were used in this study (Hereford x Angus and Angus x Hereford reciprocal crosses were combined into one group). The cows were milked out during the first week of each month from March through August on two days during that week. Half the cows were milked on each day, four from each crossbred group.

Calves were allowed to suckle their dams and then were separated 10 to 14 hours prior to milking. Ten to thirty milligrams of the tranquilizer ace promazine were given by an intramuscular injection approximately 15 minutes before milking. Immediately prior to milking, the cows were injected with 1.5 milligrams of syntocin, a synthetic oxytocin, in the jugular for milk letdown. Cows were milked out by a portable DeLaval vacuum pump milking unit. On the average, the milking time per cow was ten minutes. Each cow's udder was stripped out by hand to assure a complete milkout. The milk was weighed and two samples taken, one for a butterfat composition analysis and the other for freezing, to determine total solids and protein content at a later date. The weight of the milk and the time of milking were both recorded.

Milk samples were kept on ice for the duration of the day's milkout procedures. Samples for butterfat determination were transferred to the DHIA Laboratory at Oklahoma State University for analysis by a milk-o-tester. Butterfat analysis were completed within four days of milking. The other samples were stored in a freezer at the OSU meat laboratory. Unfortunately, the samples that had been frozen, curdled, so the analysis for total solids and protein content could not be done.

Statistical Analysis

The majority of data in this study were analyzed by procedures available in the Statistical Analysis System (SAS), a generalized computer program developed by Barr and Goodnight (1972 and 1976). Adjusted means, unless otherwise stated, were tested for significant differences by Duncan's protected multiple range tests as modified by Kramer (1957).

Cow Productive Traits

Since reproductive data are based on a binomial distribution (pregnant vs non-pregnant) rather than a normal distribution, a SAS

(1976) procedure was used to develop two-way frequency tables that were tested by chi-square for homogeneity. Breed of sire of the calf did not contribute significantly to differences in reproduction and was thus eliminated from further tests.

The two-way tables that were developed were crossbred dam group by birthtype, crossbred dam group by calving difficulty scores, crossbred dam group by calving type, crossbred dam group by weaning type and crossbred dam group by rebreeding performance. Table III explains each of the traits.

To test for differences among the crossbred dam groups, procedures developed by K. R. Gabriel (1966) for multiple comparisons on categorical data were used. This procedure avoids the assumption of equal variances assumed for the dependent variable in regression analysis since equal variances may not hold for binomial traits. It also allows for testing of traits such as calving difficulty scores which have more than two frequency levels.

Gabriel's procedures can be applied to each pair of rows from the original two-way table or to any other subset of rows. It is based on the actual frequencies in the tables. In the following two-way table:

$$
\begin{array}{cccc|c}
n_{11} & n_{12} & \cdots & n_{1r} & n_{1.} \\
n_{21} & n_{22} & \cdots & n_{2r} & n_{2.} \\
\vdots & \vdots & & \vdots & \vdots \\
n_{k1} & n_{k2} & & n_{kr} & n_{k} \\
\hline
n_{.1} & n_{.2} & \cdots & n_{.r} & n_{..}
\end{array}
$$

the value of I is calculated for each set of row comparisons by:

TABLE III

REPRODUCTIVE TRAITS

Trait	Designation	Description
Birthtype	0	Cow open
	1	Calf born alive
	2	Calf born but dead before 24 hrs.
Calving Type	0	No difficulty (a score of 1 or 2)
	1	Difficulty (a score of 3, 4 or 5)
Weaning Type	0	Calf died from birth to weaning
	1	Calf alive at weaning
Rebreeding Performance	0	Cow did not rebreed
	1	Cow rebred
Calving Difficulty Scores	1-5	See Table II

$$I = \sum_i \sum_j n_{ij} \log n_{ij} - \sum_i n_{i.} \log n_{i.} - \sum_j n_{.j} \log n_{.j} + n_{..} \log n_{..}$$

The value of 2I is distributed as X^2 with $(k-1)\cdot(r-1)$ degrees of freedom. The group being tested is rejected for homogeneity if 2I is greater than the upper 5% value of the tabular X^2 with proper degrees of freedom.

Calf, Cow Efficiency, Cow Weight and Cow Score Traits

The calf traits and cow efficiency traits were analyzed on data from 334 calves and their dams by a SAS (1972) regression procedure by the following linear model:

$$Y_{ijklm} = \mu + C_i + Y_j + S_k + X_l + YS_{jk} + CY_{ij} + YX_{jl} + CS_{ik} + SX_{kl} + CX_{il} + CSX_{ikl} + e_{ijklm}$$

where

Y_{ijklm} = the observed trait of the ijklmth observation.

μ = population mean.

C_l = fixed effect of the ith crossbred dam group; i = 1, 2, 3, 4, 5, 6, 7, 8.

Y_j = fixed effect of the jth year; j = 1, 2, 3.

S_k = fixed effect of the kth sirebreed of the calf; k = 1, 2.

X_l = fixed effect of the lth sex of the calf; l = 1, 2.

YS_{jk} = interaction of the jth year and the kth sirebreed of the calf.

CY_{ij} = interaction of the ith crossbred dam group and the jth year.

YX_{jl} = interaction of the j^{th} year and the l^{th} sex of calf.

CS_{ik} = interaction of the i^{th} crossbred dam group and the k^{th} sirebreed of the calf.

SX_{kl} = interaction of the k^{th} sirebreed of the calf and the l^{th} sex of the calf.

CX_{il} = interaction of the i^{th} crossbred dam group and the l^{th} sex of the calf.

CSX_{ikl} = interaction of the i^{th} crossbred dam group, k^{th} sirebreed of the calf and l^{th} sex of the calf.

e_{ijklm} = random error associated with the $ijklm^{th}$ observation.

The traits involved in the analysis included birthweight, calving difficulty score, preweaning average daily gain, 205-day weaning weight, weaning conformation score, weaning condition score, the ratio of calf weaning weight to cow weight and the ratio of calf weaning weight to cow metabolic weight. The analysis for each trait by the full model was conducted to determine significant sources of variation, then non-significant sources of variation were eliminated from the model for each trait to calculate least square means. Means were adjusted for all significant main effects and two factor interactions in the reduced models.

The cow weight and condition scores were analyzed by SAS (1976) general linear models procedure since there were some empty cells in the data set. The linear model used was:

$$Y_{ijkl} = \mu + C_l + Y_j + D_k + CY_{ij} + CD_{ik} + YD_{jk} + CYD_{ijk} + e_{ijkl}$$

where

Y_{ijkl} = the observed trait of the $ijkl^{th}$ observation.

μ = population mean.

C_i = fixed effect of the i^{th} crossbred dam group; i = 1, 2, 3, 4, 5, 6, 7, 8.

Y = fixed effect of the j^{th} year; j = 1, 2, 3.

D_k = fixed effect of the k^{th} month of calving, k = 1, 2, 3.

CY_{ij} = interaction of the i^{th} crossbred dam group and the j^{th} year.

CD_{ik} = interaction of the i^{th} crossbred dam group and the k^{th} month of calving.

YD_{jk} = interaction of the j^{th} year and the k^{th} month of calving.

CYD_{ijk} = interaction of the i^{th} crossbred dam group, j^{th} year and k^{th} month of calving.

e_{ijkl} = random error associated with the $ijkl^{th}$ observation.

The traits involved in this portion of the analysis were cow spring weight, fall weight, average weight, summer weight gain, spring condition score, fall condition score and average condition score. The reduced model analysis for each trait was conducted on SAS (1972) programs to obtain means adjusted for all significant main effects and two-factor interactions.

The yearling weights and condition scores were analyzed by a SAS (1972) regression procedure by the following linear model:

$$Y_{ijk} = \mu + C_i + Y_j + CY_{ij} + e_{ijk}$$

where

Y_{ijk} = the observed trait of the ijk^{th} observation.

μ = the population mean.

C_i = the fixed effect of the i^{th} crossbred cow group; i = 1, 2, 3, 4, 5, 6, 7, 8.

Y_j = the fixed effect of the j^{th} year; j = 1, 2, 3.

CY_{ij} = interaction of the i^{th} crossbred cow group and the j^{th} year.

e_{ijk} = random error associated with the jkl^{th} observation.

The means for yearling weight and condition scores were adjusted for the full model effects, since all were significant sources of variation in the analysis.

Milk Traits

Since cow-calf separation time to milking varied from 10 to 14 hours, adjustments in milk traits were made to a 12-hour basis. Crossbred dam group was tested within each month through a SAS (1972) regression procedure to determine if the regression coefficients of the lactation curves from 10 to 14 hours were similar among crossbred groups. Differences were non-significant, therefore the regression coefficients were pooled over crossbred dam groups and the following model was used to determine adjustment factors for adjusting milk yield to a 12 hour basis:

$$Y_{ijk} = \mu + C_i + H_j + H_j^2 + e_{ijk}$$

where

Y_{ijk} = the observed milk trait of the ijk^{th} observation.

μ = population mean.

C_i = fixed effect of the i^{th} crossbred dam group; i = 1, 3, 4, 5, 6, 7, 8.

H_j = fixed effect of the j^{th} hour of separation; j = 10 to 14.

H_j^2 = fixed effect of the j^{th} hour of separation, squared.

e_{ijk} = random error associated with the ijk^{th} observation.

The quadratic term in the model was non-significant and deleted. Regression coefficients were determined for each month's lactation curve from 10 to 14 hours and the pooled estimate from April through August was used to correct milk yield to 12 hour production. Twenty-four hour production was estimated by doubling the adjusted 12-hour milk yield. The formula to adjust milk yields used was:

$$\text{ADJ. 24-HR MILK YIELD} = [.252\ (\text{12-Actual Hrs of Separation}) + \text{Actual Milk Yield}] \times 2$$

The regression coefficients for the butterfat percent over the range of separation times were very small and not different from zero, therefore no correction to 12 hour production was made for butterfat. Pounds of fat produced per day was estimated by:

$$\text{24-HR BUTTERFAT YIELD} = \text{ADJ. 24-HR MILKYIELD} \times \text{BUTTERFAT \%}$$

The data was then tested for influence of breed of sire of the calf on milk traits by regression procedures on a within month basis. Breed of sire of the calf and the interaction of breed of sire and crossbred dam group were both found to be non-significant and deleted from further analysis. Since each crossbred dam group had an equal number of steer and heifer calves suckling, sex of calf was not considered in any model.

There were two milkdays each month during the data collection. A regression analysis was conducted to determine if the effects of crossbred dam group, milkday and interaction between the two were significant on a monthly basis. The linear model used was:

$$Y_{ijk} = \mu + C_i + M_j + CM_{ij} + e_{ijk}$$

where

Y_{ijk} = the observed milk trait of the ijkth observation.

μ = population mean.

C_i = Fixed effect of the ith crossbred dam group; i = 1, 3, 4, 5, 6, 7, 8.

M_j = fixed effect of the jth milkday; j = 1, 2.

CM_{ij} = interaction of the ith crossbred dam group and the jth milkday.

e_{ijk} = random error associated with the ijkth observation.

The milk traits involved in the analysis were 24-hour milk yield, butterfat percent and 24-hour butterfat yield. Differences between crossbred dam groups for all milk traits were tested for significance by protected Duncan's multiple range tests. Since there were equal numbers in each data cell, the modification by Kramer was not necessary.

To look at crossbred group differences over months, a split-plot design was used with crossbred dam groups as main units and months as subunits. Regression procedures were conducted on the following model:

$$Y_{ijkl} = \mu + C_i + \beta_{ij} + A_k + CA_{ik} + e_{ijkl}$$

where

Y_{ijkl} = the observed milk trait of the ijklth observation.

μ = population mean.

C_i = fixed effect of the ith crossbred dam group; i = 1, 3, 4, 5, 6, 7, 8.

β_{ij} = random effect of the jth cow within the ith crossbred dam group; j = 1, 2, 3, 4, 5, 6, 7, 8.

A_k = fixed effect of the kth month; k = 1, 2, 3, 4, 5, 6.

CA_{ik} = interaction of the ith crossbred dam group and the kth month.

e_{ijkl} = random error associated with the ijklth observation.

Crossbred dam group effect was tested by cow within crossbred group. Month and crossbred group by month interaction were tested by residual error.

In addition to the above analysis, simple correlations were determined between dam 24-hour milk yield and calf ADG to weaning; dam 24-hour milk yield and calf 205-day weight; butterfat percent and calf ADG; butterfat percent and calf 205-day weight; 24-hour butterfat yield and calf ADG; and 24-hour butterfat yield and calf 205-day weight. Correlations within each crossbred dam group for the above trait pairs were also calculated and pooled. Confidence intervals for the correlations were determined by Z-transformations as described by Steel and Torrie (1960).

The data was also subjected to a stepwise regression procedure and minimum and maximum R^2 procedures (SAS, 1972) to determine R^2 values using 24-hour milk yield, butterfat percent and 24-hour butterfat yield to predict calf 205-day weight and calf ADG to weaning. Crossbred dam group effects were then removed from the data and the same procedures again applied to determine R^2 values without crossbred dam group effects in the variables.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter will be divided into three main sections comparing crossbred cow groups: 1) reproductive traits; 2) productivity and efficiency traits; and 3) milk production traits.

Reproductive Traits

Table IV presents chi-square values for the two-way tables of crossbred cow groups by various reproductive traits such as cows calving, calving difficulty, birthtype and weaning type. Significant chi-square values, indicating significant differences among crossbred cow groups, were obtained for all traits except weaning type. Crossbred cow groups did not differ significantly for this trait largely due to the small number of calves that died from birth to weaning in the total group.

Table V presents reproductive traits by crossbred dam groups as percentages. Eighty-four percent of all cows exposed to breeding calved, ranging from 57.8% for SH cows to 94.9% for JH cows. The Jersey crosses, BA and AH cows were similar and averaged 91.6% cows calving while BH, SA and HA were lower but not significantly different at 78.0%, 81.2% and 85.1%, respectively. The SH group had the poorest calving performance at 57.8 percent.

The difference between the percent calving and percent live born indicates early calf mortality (within 24 hours of birth). Of the cows

TABLE IV

CHI-SQUARE VALUES FROM TWO-WAY TABLES OF CROSSBRED COW REPRODUCTIVE TRAITS

Two-way Tables	Degrees of Freedom	Chi-square Value	Probability
Crossbred cow group (1 thru 8) by cows calving (0 or 1)	7	38.9	.01
Crossbred cow group (1 thru 8) by calving difficulty scores (1 thru 5)	28	46.2	.02
Crossbred cow group (1 thru 8) by calving difficulty (1 or 2)	7	15.7	.03
Crossbred cow group (1 thru 8) by birthtype (0, 1 or 2)	14	49.1	.01
Crossbred cow group (1 thru 8) by weaning type (0 or 1)	7	8.0	.33

TABLE V

REPRODUCTIVE PERFORMANCE OF TWO-YEAR OLD CROSSBRED COWS

Crossbred Cow Group[1]	No. Cows Exposed	No. Cows Calving	Ave. Calving Date	Percent Calving[2]	Percent Live Calves Born	Percent Calves Weaned[2]	Percent Cows Rebred[3]
HA	47	40	2/9	$85.1^{a,b}$	$74.5^{a,b}$	$68.1^{b,c}$	$72.5^{a,b,c}$
AH	58	51	2/12	87.9^{a}	$79.3^{a,b}$	$75.9^{a,b,c}$	$72.5^{a,b,c}$
SA	69	56	2/11	$81.2^{a,b}$	$72.4^{a,b}$	$72.4^{a,b,c}$	$73.2^{a,b,c}$
SH	45	26	2/26	57.8^{b}	55.6^{b}	53.3^{b}	$60.0^{b,c}$
BA	47	44	2/6	93.6^{a}	$87.2^{a,b}$	$85.1^{a,b,c}$	$67.4^{b,c}$
BH	50	39	2/12	$78.0^{a,b}$	$76.0^{a,b}$	$72.0^{a,b,c}$	43.6^{b}
JA	59	53	2/6	89.8^{a}	88.1^{a}	$88.1^{a,c}$	$84.9^{a,c}$
JH	59	56	2/2	94.9^{a}	91.5^{a}	91.5^{a}	92.9^{a}
Overall	434	365	2/10	84.1	78.6	76.5	73.0

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

[2]Based on number of cows exposed in the breeding herd.

[3]Based on number of cows calving.

[a,b,c]Means in the same column that do not share at least one superscript are significantly different ($P < .05$).

exposed to breeding, 78.6% gave birth to a live calf, reflecting an overall early calf mortality of 5.5 percent. The Jersey crosses had the highest percent of live calves born averaging 89.8% followed by Brown Swiss crosses at 81.6%, HA reciprocal crosses at 76.9% and SA cows at 72.4 percent. Early calf mortality ranged from JA (1.7%) to HA (10.6%) cows.

Reports in the literature on these traits for these particular crosses are varied. Laster et al. (1976) observed HA reciprocal cross cows had a higher pregnancy rate as two-year-olds than Jersey or Simmental crosses (93% vs 86%), ranging from 96.2% for AH to 79% for JA cows. The USMARC Progress Report No. 2 (1975) reported an overall percent of live calves born of 85.4% which is slightly higher than the 78.6% observed in the present study. The USMARC data did not show any difficulty for the SH cows in percent conception. This could be attributed to overall heavier cow weights at first breeding than observed in the present study.

USMARC Progress Report No. 5 (1977) involving other crossbred cows, including BA, BH, HA and AH, indicated that Brown Swiss crosses were higher in percent live calves born than HA reciprocal crosses (92.2% vs 82.6%) as compared to this study which did not obtain significance differences between those particular crossbred groups. Freeden et al. (1974) reported for two-year old SH, SA and HA cows, pregnancy rates of 85.1%, 82.2% and 86.5%, respectively, again not observing any reproductive difficulty for SH heifers.

Overall, 76.5% of the 434 cows exposed to breeding weaned a calf which is similar to that reported in USMARC Progress Report No. 2 (1975) of 77.9% calf crop weaned. There was considerable variation among crossbred groups for this trait. Jersey crosses weaned the highest percentage of calves (averaged 89.8%). Brown Swiss crosses, AH and SA cows were similar to Jersey crosses but lower (averaged 76.4%). Of the HA cows exposed to breeding 68.1% weaned a calf while SH cows had the poorest reproductive performance with only 53.3% weaning calves. Freeden et al. (1974) who reported SA and HA reciprocal crosses similar at 80.3% and SH cows lower at 74.7% calf crop weaned.

A critical period in the reproductive management of young cows is the breeding season following birth of their first calf at two-years of age. Rebreeding performance of those crossbred heifers is presented in the last column of Table V. Overall, 73% of the crossbred cows calving as two-year olds rebred, ranging from 92.9% for JH cows to 43.6% for BH group. Jersey x Angus cows had a rebreeding percent of 84.9% followed by HA, AH and SA cows who were all similar and averaged 72.7 percent. The SH and BA had poorer rebreeding performances of 60.0% and 67.4%, respectively. This data is in agreement with USMARC Progress Report No. 2 (1975) that reported Jersey crosses as having the highest rebreeding performance at 93.7 percent. However, this study does not agree with USMARC Progress Report No. 5 (1977) that observed Brown Swiss crosses at 93.4% rebreeding similar to HA reciprocal crosses at 90.2% rebred.

Table VIII presents mean squares for calf birth weights and average calving difficulty scores. Year of calving, crossbred dam group and sex of calf were significant sources of variation for both traits. Only one interaction, year by crossbred dam group was significant for average calving score.

Table VI presents the calving performance of two-year old cross-

TABLE VI

CALVING PERFORMANCE OF TWO-YEAR OLD CROSSBRED COWS[2]

Crossbred Cow Group[1]	No. Cows Calving	Calf Birth Weight (lb)[3]	Calving Difficulty Score[3,4]	Percent Calving Difficulty[4]
HA	40	63.1 ± 1.2[b]	1.62 ± .18[b]	25.0[a,b]
AH	51	60.9 ± 1.0[b]	2.21 ± .15[a]	37.3[a,b]
SA	56	68.5 ± 1.0[a]	2.05 ± .14[a,b]	35.7[a,b]
SH	26	66.7 ± 1.4[a]	2.40 ± .20[a]	50.0[b]
BA	44	66.7 ± 1.1[a]	1.61 ± .16[b]	18.2[a,b]
BH	39	67.4 ± 1.1[a]	2.04 ± .17[a,b]	28.2[a,b]
JA	53	57.9 ± 1.0[c]	1.71 ± .14[b]	20.7[a,b]
JH	56	60.9 ± 1.0[b]	1.58 ± .14[b]	17.9[a]
Total or Average	365	64.0	1.90	27.9

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

[2]Calves sired by Red Poll and Shorthorn bulls.

[3]Adjusted means and standard errors: means adjusted for all significant main effects and interactions.

[4]Calving difficulty scores: 1 = no difficulty, 2 = little difficulty, 3 = moderate difficulty, 4 = major difficulty and 5 = caesarian. A score of 3 or more is considered a difficult birth.

[a,b,c]Means in the same column that do not share at least one superscript are significantly different ($P < .05$).

bred cows by crossbred dam group. The means for calf birth and calving score were adjusted for year and sex of calf. Calving score was also adjusted for the year by crossbred dam group interaction. Calving difficulty was also reported as percent difficult births which were those with a calving score of three or more. Each calf was observed during birth and given a calving score by the herdsman. (Calving scores described in Table II.)

Over, 365 cows calved. Birthweights varied, with the heaviest calves produced by Simmental and Brown Swiss crosses averaging 67.3 pounds. The JH and HA reciprocal cross cows had calves intermediate in birthweight (averaged 61.6 lb) while the lightest calves were produced by JA cows at 57.9 pounds.

The Jersey crosses, HA and BA cows had the lowest average calving score (averaged 1.63). The BH and SA cows were intermediate at 2.04 and 2.05, respectively. The AH and SH cows experienced the most difficulty with average scores of 2.21 and 2.40, respectively. Percent calving difficulty followed a similar pattern. Jersey x Hereford cows experienced the least difficulty at 50.0 percent. The other crossbred groups were similar and intermediate (averaged 27.5%).

Table VII presents the percentages of cows for each level of calving difficulty scores for each crossbred cow groups. Overall, as two-year olds, 51.8% of the cows had no difficulty at birth with a calving score of one and 20.3% had a score of two, indicating assistance was given but not necessary. Moderate difficulty, a score of three, was experienced by 18.4% of the cows, in which a jack or calf puller was used and a total of 7.1% required major assistance. A total of 2.5% of the calves were delivered by ceasarean. The easiest calvers, with

TABLE VII

CALVING DIFFICULTY SCORES OF TWO-YEAR OLD CROSSBRED COWS

Crossbred Cow Group[2]	No. Cows Calving	1 %	2 %	3 %	4 %	5 %
HA	40	50.0	25.0	20.0	5.0	0.0
AH	51	35.3	27.5	19.6	9.8	7.8
SA	56	39.3	25.0	17.9	12.5	5.4
SH	26	30.8	19.2	42.3	7.7	0.0
BA	44	63.6	18.2	15.9	2.3	0.0
BH	39	56.4	15.4	15.4	10.3	2.5
JA	53	67.9	11.3	13.2	7.5	0.0
JH	56	62.5	19.6	14.3	1.2	1.2
Overall	365	51.8	20.3	18.4	7.1	2.5

[1] Percentages based on the number of cows calving. Calving difficulty scores: 1 = no difficulty, 2 = little difficulty, 3 = moderate difficulty, 4 = major difficulty, and 5 = caesarian.

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

scores of 1, were the Jersey crosses and BA cows that averaged 64.7% unassisted births. Simmental x Hereford cows had the highest percentage that received a calving score of three, which indicate moderate difficulty (42.3%) and BH, SA and AH cows required the largest percentage receiving a score of 4, indicating major assistance (10.3%, 12.5% and 9.8%, respectively).

Calves from Jersey crosses had the lightest birthweights (59.3 lb) which perhaps accounts for some of their easier calving. However, BA cows which had calves averaging 66.7 lb at birth, one of the heaviest birthweights, only experienced 18.2% calving difficulty. Calving difficulty and other reproductive traits summarized by year are reported in Appendix Table XXV on each crossbred dam group. Year to year there are changes in magnitudes, however, the crossbred cow groups tend to maintain similar rankings on the various reproductive traits.

The calving data tends to be in general agreement with previous studies. USMARC Progress Report No. 2 (1975) reported heaviest calf birth weights for Simmental crosses and lightest birthweights for Jersey crosses. They also reported Simmental cross cows experienced the most calving difficulty (46.1%). Progress Report No. 5 (1977) for Brown Swiss and HA reciprocal crosses reported heavier birth weights (+ 5.8 lb) and less calving difficulty (-18.2%) for the Brown Swiss crosses than HA and AH cows.

Bowden et al. (1977) also reported the calves born to JA cows were lightest at birth when compared to HA and SA cow groups and that JA cows also experienced the least difficulty. However, Freeden et al. (1974) found similar calving difficulties for SH, SA, HA and AH cows, but heavier birth weights for calves from Simmental cross cows (+ 7.4

lb).

Productivity and Efficiency Traits

Table VIII presents mean squares of the analysis of variance for traits of three-breed cross calves produced by two-breed cross cows. Year of birth, crossbred dam group and sex of calf were significant sources of variation for all calf traits. Sirebreed of calf was also significant source of variation for calf weaning conformation and condition scores. Only four interactions were significant for calf traits. The year by crossbred dam group interaction was significant for calving score, as previously mentioned, and for weaning conformation score. Year by sex was also a significant source of variation for weaning conformation score. The means presented on these traits are adjusted for all significant main effects and significant interactions. The mean squares of analysis of variance for each trait's reduced model are reported in Appendix Table XXVI.

Table IX presents adjusted means and standard errors for preweaning average daily gain, 205-day weaning weight and weaning conformation and condition scores by crossbred dam groups. A total of 334 calves were weaned over the three year period. Overall, these calves had preweaning gains of 1.69 pounds per day. Calves from the BA cows gained the most rapidly, averaging 1.86 lb/day while Simmental crosses, Jersey crosses and BH cows had calves with intermediate gains (averaged 1.73 lb/day). The slowest gains from birth to weaning were observed in calves from HA reciprocal cross cows (1.51 lb/day).

Weaning weights adjusted to 205-days of age are presented in the fourth column of Table IX. Column five presents these weights on a per-

TABLE VIII

MEAN SQUARES FOR CROSSBRED CALF TRAITS

Source	df	Calf Birth Weight (lb)	Calving Difficulty Score	Pre-Weaning ADG (lb/Day)	Weaning Conformation	Weaning Condition	205-Day Weaning Weight
Year (Y)	2	575.41**	4.32*	.50**	9.10**	5.56**	28306.50*
Sirebreed of Calf (S)	1	113.14	2.23	.06	14.21**	8.32**	769.28
Crossbred Dam Group (C)	7	555.72**	2.79*	.56**	7.35**	2.01**	25970.17**
Sex of Calf (Sx)	1	833.25**	9.58**	.44**	2.94*	3.91**	24667.71**
YxS	2	61.76	.02	.05	.50	.77	1847.05
YxC	14	59.95	2.72*	.03	1.67**	.76	1311.43
YxSx	2	90.11	1.30	.02	6.06**	1.44*	2033.50
SxC	7	14.81	.99	.03	.38	.48	1391.89
SxSx	1	105.65	.23	.03	.03	.03	1125.23
CxSx	7	89.21	1.10	.04	.37	.33	2073.53
SxCxSx	7	37.39	.38	.02	.23	.64	1477.15
Error	282	51.59	1.15	.03	.69	.55	1449.72

*P < .05; **P < .01.

TABLE IX

PERFORMANCE TO WEANING OF THREE-BREED CROSS CALVES PRODUCED BY TWO-BREED CROSS COWS[2]

Crossbred Cow Group[1]	No. Calves	Pre-Weaning ADG (lb/Day)	Weaning Conformation	Weaning Condition[4]	205-Day Weaning Weight lb.	% HA[6]
HA	33	$1.50 \pm .03^{c}$	$12.5 \pm .1^{b}$	$5.0 \pm .1^{a,b,c}$	370 ± 6^{c}	100.0
AH	45	$1.51 \pm .03^{c}$	$12.5 \pm .1^{b}$	$4.7 \pm .1^{c}$	371 ± 5^{c}	100.0
SA	50	$1.73 \pm .02^{b}$	$13.1 \pm .1^{a}$	$5.3 \pm .1^{a,b}$	424 ± 5^{b}	114.4
SH	24	$1.70 \pm .03^{b}$	$13.0 \pm .2^{a}$	$4.9 \pm .1^{b,c}$	413 ± 7^{b}	111.5
BA	40	$1.86 \pm .03^{a}$	$13.4 \pm .1^{a}$	$5.3 \pm .1^{a,b}$	448 ± 6^{a}	120.9
BH	36	$1.73 \pm .03^{b}$	$13.1 \pm .1^{a}$	$5.3 \pm .1^{a,b}$	423 ± 6^{b}	114.2
JA	52	$1.74 \pm .02^{b}$	$12.5 \pm .1^{b}$	$5.3 \pm .1^{a}$	416 ± 5^{b}	112.3
JH	54	$1.74 \pm .02^{b}$	$12.3 \pm .1^{b}$	$5.2 \pm .1^{a,b}$	417 ± 5^{b}	112.6
Total or Average	334	1.69	12.8	5.1	410	

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

[2] Adjusted means and standard errors: means adjusted for all significant main effects and interactions.

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

[4] Condition score equivalents: range from 1 = very thin to 5 = average to 9 = very fat.

[5] Weaning weights were adjusted only for the age of calf. Steer and heifer weights were averaged.

[6] Based on the average of the HA and AH reciprocal crosses = 100 percent.

[a,b,c] Means in the same column that do not share at least one superscript are significantly different ($P < .05$).

centage basis to compare production to the HA reciprocal cross groups (HA and AH cow averages = 100%). Overall, calves were 410 lb at weaning. The ranking of crossbred dam groups exactly follows that of preweaning average daily gain with the BA cows producing the heaviest calves averaging 448 lb and exceeding HA crosses by 21 percent. Jersey crosses, Simmental crosses and BH cows produced calves similar in weaning weight at 419 lb on the average, 13.0% heavier than calves from HA and AH cows. The HA reciprocal cross cows produced the lightest calves at 369 pounds.

This data is in agreement with most reported in the literature. Parker (1975) observed in a study involving Angus (A), Charolais (C), AC, CA, JA, JC, BA and BC cows that dairy crosses weaned calves 62.6 lb heavier than straighbred or crossbred beef cows (415.4 vs 352.8 lb). Holzgraefe et al. (1976) also reported heavier weaning weights for dairy crosses when compared to AH cows (423 vs 353 lb). Notter et al. (1978) reported Jersey and Simmental cross cows had the heaviest calves at weaning (399 lb) and HA reciprocal cross cows produced the lightest calves averaging 362 pounds.

Overall, these three-breed cross calves were very uniform in conformation. Calves from HA, AH and Jersey crosses averaged low choice in conformation while others were average choice. Calves were also very uniform in condition with calves from HA, AH and SH slightly below average at 5.0, 4.7 and 4.9, respectively, and the other groups above average (score of 5.3). The performance to weaning of these three-breed cross calves by year is presented in Appendix Table XXVII. Generally, the differences from year to year are in magnitude rather than changes in crossbred dam group rankings. However, for the average calving difficulty score, rankings changed considerably from one year to the next with no apparent explanation.

In Table X, comparisons among crossbred dam groups in total productivity for the breeding herd were made by combining the percentage of cows exposed that weaned calves with the respective weaning weights to obtain the pounds of calf weaned per cow exposed in the breeding herd. Simmental x Hereford cows were 54 lb (19.7%) lower in productivity than the HA reciprocal cross group. The Jersey crosses and BA cows were the most productive averaging 103 lb (37.5%) more pounds of calf weaned per cow exposed than the HA and AH cows. The SA and BH cows were 32 lb (11.7%) more productive. This data is in agreement with that published by Freeden et al. (1974) who reported SA, SH and HA reciprocal crosses weaning 334, 315 and 297 lb of calf per cow exposed, respectively.

Mean squares of analysis of variance for crossbred yearling weights and condition scores are presented in Table XI. Crossbred cow group, year and the interaction between the two were all significant sources of variation, therefore means presented for yearling weight and yearling condition score are adjusted for year and the year by crossbred cow group interaction. Table XII presents mean squares of analysis of variance for crossbred cow weights and condition scores. Crossbred cow group was a significant source of variation for all traits and year was significant for all traits except cow spring weight. The interaction of these two sources of variation was significant for all cow condition score traits. Month of calving also had a significant effect on spring weight and score and summer weight gain. This was expected, as all cows were given condition scores and weighed on the same day and not individually, a set number of days after calving. There was a three to four

TABLE X

WEANING WEIGHT PRODUCTION PER CROSSBRED COW IN THE BREEDING HERD

Crossbred Cow Group[1]	No. Cows Exposed	Pounds of Calf Weaned Per Cow Exposed	
		lb.	% HA[2]
HA	47	260	100.0
AH	58	288	
SA	69	307	112.0
SH	45	220	80.3
BA	47	381	139.1
BH	50	305	111.3
JA	59	367	133.9
JH	59	382	139.4

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

[2]Based on the average of the HA and AH reciprocal crosses = 100 percent.

TABLE XI

MEAN SQUARES FOR CROSSBRED HEIFER YEARLING TRAITS - FULL MODEL

Source	Degrees of Freedom	Yearling Weight	Yearling Score
Crossbred Cow Group (C)	7	51978.77**	9.88**
Year (Y)	2	91758.04**	5.66**
CxY	14	4375.54*	10.40**
Error	407	2241.81	.38

*P < .05; *P < .01.

TABLE XII

MEAN SQUARES FOR CROSSBRED COW TRAITS - FULL MODEL

Source	df	Cow Spring Weight (lb)	Cow Fall Weight (lb)	Average Cow Weight (lb)	Summer Weight Gain (lb)	Spring Condition Score	Fall Condition Score	Average Score
Crossbred Cow Group (C)	7	82,789.98**	110,007.12**	95,049.80**	5,394.97**	11.33**	15.39**	13.01**
Year (Y)	2	1,820.58	48,380.05**	12,263.11*	51,348.79**	80.59**	17.14**	42.83**
CxY	14	4,424.90	5,042.12	4,440.17	1,173.39	1.72**	1.66**	1.20**
Calving Date (CD)	2	20,838.40**	3,486.41	7,637.21	18,100.77**	6.12**	.16	1.19*
CxCD	14	2,268.44	2,444.22	2,032.34	1,295.97	.57	1.21*	.51
YxCD	4	12,647.84**	6,149.91	8,662.43*	2,945.77*	5.11**	.06	1.12*
CxYxCD	18	3,308.92	6,594.17	4,407.17	2,177.49*	.80	1.24	.75
Error	271	3,032.83	4,119.73	3,256.86	1,277.68	.75	.76	.50

*P < .10; **P < .01.

month interval for calving from the first of January to the middle of April. The year by month of calving interaction was significant for cow spring weight, average weight and spring condition score while the crossbred cow group by calving date interaction significantly affected fall condition score. The three-way interaction of crossbred cow group, year and calving date was significant for summer weight gain. Most significant interactions were generally of small magnitude when compared to other significant sources of variation.

The weight and condition score traits presented in Tables XIII and XIV are adjusted for all significant main effects and significant two-way interactions. Appendix Table XXVIII presents mean squares of analysis of variance from the reduced models for each cow weight and condition score trait.

The adjusted means and standard errors for cow weight traits are presented in Table XIII by crossbred cow group. These traits by year are presented in Appendix Table XXIX. Generally, differences from year to year are in magnitude rather than crossbred cow group ranking. As yearling, SA heifers were heaviest, averaging 551 lbs, followed by BA heifers at 532 pounds. The SH, BH and HA crosses were intermediate, averaging 501 lb as yearlings, while the AH were 485 lb on the average. The Jersey crosses were lightest as yearlings at 467 pounds.

The cow spring weights were taken in April of each year after their first calving and prior to entering the breeding pastures. The cow herd averaged 679 lb as two-year olds at this time, ranging from SA cows at 746 lb to Jersey crosses and AH cows averaging 636 pounds. The SH and BA cows were similar and averaged 705 lb while the HA and BH groups were slightly lower, averaging 685 pounds. Fall weights, taken after

TABLE XIII

ADJUSTED MEANS AND STANDARD ERRORS FOR CROSSBRED COW WEIGHTS[2]

Crossbred Cow Group[1]	No. Lactating Cows	Yearling Weight (lb)[6]	Cow Spring Weight (lb)[3]	Cow Fall Weight (lb)[4]	Average Cow Weight (lb)[5]	Summer Weight Gain (lb)
HA	33	$493 \pm 7^{c,d}$	685 ± 9^{c}	783 ± 11^{b}	729 ± 9^{b}	$98 \pm 6^{a,b}$
AH	44	485 ± 6^{d}	645 ± 8^{d}	741 ± 9^{c}	688 ± 8^{c}	$95 \pm 5^{a,b}$
SA	50	551 ± 6^{a}	746 ± 8^{a}	845 ± 9^{a}	792 ± 8^{a}	$97 \pm 5^{a,b}$
SH	24	509 ± 7^{c}	$696 \pm 11^{b,c}$	801 ± 12^{b}	746 ± 11^{b}	105 ± 7^{a}
BA	40	532 ± 7^{b}	714 ± 8^{b}	796 ± 10^{b}	751 ± 9^{b}	$83 \pm 5^{b,c}$
BH	36	$501 \pm 6^{c,d}$	685 ± 9^{c}	770 ± 10^{b}	724 ± 9^{b}	$85 \pm 6^{a,b}$
JA	52	467 ± 6^{e}	634 ± 8^{d}	701 ± 9^{d}	662 ± 8^{c}	68 ± 5^{c}
JH	54	467 ± 6^{e}	628 ± 8^{d}	710 ± 9^{d}	664 ± 8^{c}	$85 \pm 5^{a,b}$
Total or Average	333	501	679	768	720	90

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

[2]Adjusted means and standard errors: means adjusted for all significant main effects and interactions.

[3]Weight taken after first calving.

[4]Weight taken after first weaning.

[5]Average of Spring and Fall Weights.

[6]Based on number of yearling heifers.

[a,b,c,d,e]Means in the same column that do not share at least one superscript are significantly different ($P < .05$).

TABLE XIV

ADJUSTED MEANS AND STANDARD ERRORS FOR CROSSBRED COW CONDITION SCORES[2]

Crossbred Cow Group[1]	No. Lactating Cows	Yearling Condition[3,7]	Spring Condition[3,4]	Fall Condition[3,5]	Average Condition[3,6]
HA	33	$4.7 \pm .1^{b,c}$	$5.0 \pm .2^{a}$	$5.5 \pm .2^{a}$	$5.2 \pm .2^{a}$
AH	44	$4.2 \pm .1^{d}$	$4.1 \pm .1^{b,c}$	$5.3 \pm .1^{a}$	$4.7 \pm .1^{b,c}$
SA	50	$4.5 \pm .1^{c}$	$4.4 \pm .1^{b}$	$5.5 \pm .1^{a}$	$5.0 \pm .1^{a,b}$
SH	24	$5.0 \pm .1^{a}$	$4.4 \pm .2^{b}$	$5.1 \pm .2^{a,b}$	$4.8 \pm .2^{a,b,c}$
BA	40	$4.8 \pm .1^{a,b}$	$3.3 \pm .2^{d}$	$4.4 \pm .1^{c,d}$	$4.0 \pm .2^{d,e}$
BH	36	$4.5 \pm .1^{c}$	$3.9 \pm .2^{c,d}$	$4.7 \pm .1^{b,c}$	$4.4 \pm .2^{c,d}$
JA	52	$3.8 \pm .1^{e}$	$3.3 \pm .2^{d}$	$4.1 \pm .1^{d}$	$3.5 \pm .1^{e}$
JH	54	$3.7 \pm .1^{e}$	$3.5 \pm .2^{d}$	$4.3 \pm .1^{c,d}$	$3.6 \pm .1^{e}$
Total or Average	333	4.4	4.0	4.9	4.4

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

[2]Adjusted means and standard errors: means adjusted for all significant main effects and interactions.

[3]Condition score equivalents: range from 1 = very thin to 5 = average to 9 = extremely fat.

[4]Score given after first calving. [5]Score given after first weaning.

[6]Average of spring and fall scores. [7]Based on number of yearling heifers.

[a,b,c,d,e]Means in the same column that do not share at least one superscript are significantly different ($P < .05$).

first weaning, put the crossbred cow groups in similar rankings, but at increased weights. Overall, cows averaged 768 lb in the fall. Again, SA cows were heaviest (845 lb) followed by SH, HA and Brown Swiss crosses (averaged 788 lb). The AH cows weighed 741 lb on the average and Jersey crosses were the lightest at 706 pounds. Average cow weights are simply the average of spring and fall weights and follow similar patterns in differences between crossbred dam groups.

However, when considering the summer weight gains of these cattle, gains tend to be very similar, with an average gain of 90 pounds. The Simmental crosses, HA reciprocal crosses, BH and JH were all similar, averaging 92 pounds of gain. The BA cows gained 83 lb on the average over the summer and were similar to all other crossbred dam groups except SH cows while JA cows gained the least (68 lb) through the summer months.

The two-year-old cow weights for the crossbred groups in this study tend to differ somewhat from that found in other studies. In USMARC Progress Report No. 2 (1975) cow weights varied from the SH as the heaviest cows at 958 lb to the JA at 791 pounds. Their estimates tend to be about 150 lb heavier on the average, however, the rankings of crossbred cow groups for cow weight were similar to that of this study. In USMARC Progress Report No. 5 (1977), Brown Swiss crosses and HA reciprocal crosses were similar in cow weight while findings in this study indicate Brown Swiss crosses similar to HA cows, but heavier than AH cows. Freeden et al. (1974) reported Simmental crosses 93 lb heavier at first calving than the HA reciprocal cross cows which is in agreement with this study.

The cow condition scores are reported in Table XIV by crossbred cow group. They were assigned by a panel of three persons the same days cow weights were taken. Yearling condition scores varied from SH heifers with average fat cover scores of 5.0 to the Jersey crosses with thin fat cover (average score of 3.75). The BA, HA, SA and AH cows averaged 4.8, 4.7, 4.8 and 4.2 for condition scores, respectively. During the following spring, after the birth of their first calf, HA cows had average fat cover with scores of 5.0 while AH and Simmental crosses were lower averaging scores of 4.3 indicating less than average fat cover. The BH, BA, HJ and JA cows averaged scores of 3.9, 3.3, 3.5 and 3.3, respectively. Fall scores changed the crossbred cow group rankings slightly. The most condition was on the Simmental crosses and HA reciprocal crosses averaging scores of 5.4 while BH cows were slightly below average condition (average score of 4.7). The BA, JH and JA group were all lower in condition with scores of 4.4, 4.3 and 4.1, respectively. The average condition scores are simply the average of spring and fall scores. Crossbred group differences follow similar patterns observed for spring and fall condition scores.

It appears that breed types involved in these crosses influence condition scores with the dairy crosses tending to be thinner on exterior fat cover while beef crosses carry more exterior fat. Appendix Table XXX present the means for condition score traits by year. The crossbred dam group rankings are similar from year to year.

The mean squares of analysis of variance for cow efficiency traits are presented in Table XV. Year, crossbred dam group, sex of calf and the crossbred dam group by sex of calf interaction were all significant sources of variation for the efficiency traits. The ratio of calf weaning weight to cow weight or metabolic weight are adjusted for the sig-

TABLE XV

MEAN SQUARES FOR COW EFFICIENCY TRAITS

Source	df	Calf Wn Wt ÷ Cow Weight	Calf Wn Wt ÷ Cow Metabolic Weight
Year (Y)	2	.0349**	1.0408**
Sirebreed of Calf(s)	1	.0000	.0025
Crossbred Dam Group (C)	7	.0898**	1.7531**
Sex of Calf (Sx)	1	.0586**	1.4862**
YxS	2	.0051	.1204
YxC	14	.0033	.0632
YxSx	2	.0038	.0632
SxC	7	.0055	.1119
SxSx	1	.0008	.0275
CxSx	7	.0091*	.1976*
SxCxSx	7	.0047	.1046
Error	282	.0036	.0790

*P < .05; **P < .01.

nificant sources of variation mentioned above. The mean squares of analysis of variance from the reduced models for these traits are presented in Appendix Table XXXI.

Larger cows require more feed during the year for body maintenance and thus need to produce larger calves in order to be competitive with small cows for efficiency of production. However, body weight is not the only trait that influences cow nutritional needs. Since individual cow intakes had not been measured on these cows as two-year-olds, the best measures of cow efficiency that could be obtained are the ratios of calf weaning weight to cow weight or metabolic weight and the actual weaning performance of their calves. The ratios and standard errors are presented in Table XVI.

One measure of cow efficiency is the ratio of calf weaning weight to cow weight. On this basis, Jersey cross cows were the most efficient, weaning calves 63% of their body weight or 20% more efficient than HA reciprocal cross cows. Brown Swiss crosses were 12% more efficient, weaning calves 59% of their body weight while SH, SA and AH cows were all similar, weaning calves on the average 54% of their weights. The HA group was least efficient, but similar to SA and AH cows, weaning calves 51% of their weights. Data reported by Freeden et al. (1974) is similar to this study. They reported similar ratios of calf weight to cow weight for SH, SA, HA and AH cross cows.

Nutritional requirements to maintain a cow of a particular size is dependent upon the metabolic body size of the animal. Since differences in feed requirements between crossbred groups should be estimated with greater precision when based on metabolic cow size, the ratio of calf weight to cow metabolic weight was also considered. On this basis, as

TABLE XVI

MEASURES OF CROSSBRED COW EFFICIENCY[2]

Crossbred Cow Group[1]	No. of Cows	Calf Wn Wt ÷ Cow Wt		Calf Wn Wt ÷ Cow Metabolic Wt	
		Ratio	% HA[3]	Ratio	% HA[3]
HA	33	.517 ± .010[e]	100.0	2.68 ± .05[e]	100.0
AH	45	.537 ± .009[d,e]		2.75 ± .04[d,e]	
SA	50	.539 ± .008[d,e]	102.3	2.85 ± .04[d]	105.0
SH	24	.552 ± .012[c,d]	104.7	2.87 ± .06[c,d]	105.7
BA	40	.599 ± .009[b]	113.7	3.13 ± .04[a,b]	115.3
BH	36	.582 ± .009[b,c]	110.4	3.02 ± .04[b,c]	111.2
JA	52	.636 ± .008[a]	120.7	3.21 ± .04[a]	118.2
JH	54	.628 ± .008[a]	119.2	3.19 ± .04[a]	117.5

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

[2]Adjusted means and standard errors: means adjusted for all significant main effects and interactions.

[3]Based on the average of HA and AH reciprocal crosses = 100 percent.

[a,b,c,d,e]Means in the same column that do not share at least one superscript are significantly different ($P < .05$).

compared to HA reciprocal cross cows, Jersey crosses again were the most efficient by 18% followed by BA cows which were 15% more efficient. The BH, SH and SA cows were 11.2%, 5.7% and 5.0% more efficient than HA reciprocal cross cows. The efficiency ratios by year are presented in Appendix Table XXXII.

Milk Production Traits

Table XVII presents regression coefficients and standard errors of milk yield and percent butterfat on time interval of cow-calf separation before milkout each month. Time of separation varied from 10 to 14 hours. Averaging over the months from April through August, the milk yield of a cow increased .252 pounds per hour from 10 to 14 hours of separation. Butterfat percent did not change over the time period. The pooled regression coefficient for milk yield was used to adjust milk production to a 24-hour basis.

Table XVIII presents mean squares for the analysis of variance for milk yield, butterfat yield and butterfat percent over months. Crossbred dam group and month of lactation were significant sources of variation for all traits. The crossbred dam group by month interaction was significant for butterfat yield and butterfat percent. These interactions could be attributed to variation in the lab analysis for butterfat each month, poor sampling of milk or incomplete milkouts of some animals. In Appendix Table XXXIII, mean squares from the analysis of variance for milk traits by month are presented. Crossbred dam group was a significant source of variation for nearly all traits, all months. The day of milking each month was also a significant source of variation for milk and fat yields in March and July and for butterfat percent

TABLE XVII

REGRESSION COEFFICIENTS AND STANDARD ERRORS FOR MILK YIELD AND BUTTERFAT PERCENT TO DETERMINE ADJUSTMENTS FOR COW-CALF SEPARATION TIME

Month	Milk Yield	Butterfat %
March	.40 ± .19	-.03 ± .04
April	.27 ± .20	.00 ± .04
May	.29 ± .18	-.04 ± .07
June	.26 ± .21	.04 ± .07
July	.23 ± .16	-.03 ± .08
August	.21 ± .16	.01 ± .07

TABLE XVIII

MEAN SQUARES FOR MILK TRAITS

Source	df	Milk Yield (lb/Day)	Butterfat Yield (lb/Day)	Butterfat %
Crossbred Cow Group	6	289.82**	.431**	1.568**
Cow Within Crossbred Group (Error A)	48	25.82	.043	.382
Month	5	252.69**	.824**	8.599**
Crossbred Group by Month	30	7.22	.028**	.406**
Error B	244	5.57	.014	.224

**P < .01.

in May, June and August. There was one crossbred dam group by month interaction for butterfat percent in April.

Table XIX presents means and standard errors for 24-hour milk yields of each crossbred cow group. In this portion of the study the HA and AH cow groups have been combined and will be designated HA for all milk traits. Overall, the two-year-old cows averaged 14.17 lb/day of milk during their lactations. The BA cows were the highest milk producers averaging 16.68 lb/day and were not significantly different from BH, JA or SA cows at 16.40, 15.31 and 14.61 lb/day, respectively. The JA cows averaged 14.31 lb/day and the SH group averaged 12.29 pounds per day. The HA cows were lowest in milk production averaging 9.60 pounds per day.

Figure 1 depicts the milk yield curves over the six month lactation for each crossbred dam group. The Brown Swiss crosses were consistently the highest milk producers, followed by Jersey crosses and SH cows. Simmental x Hereford cows were intermediate in milk yield and HA cows were the lowest each month of their lactations.

Peak lactational production occurred in June (averaged 17.38 lb/day) as native range grasses improved with spring rains. The cows were also receiving increased energy supplements at this time since they were in breeding pastures from the first of May through the end of July. This, along with physiological time of maximum milk production for cattle, may be some explanation of increased milk yields over this period. Another explanation for increased yields is calf demand. Calves were, on the average, three to four months old and could challenge their dams' maximum production with their consumption.

The final month of lactation, August, was the overall lowest for

TABLE XIX

MEANS AND STANDARD ERRORS OF TWENTY-FOUR HOUR MILK YIELDS OF CROSSBRED COWS GROUPS (LB/DAY)

Crossbred Group[1]	March	April	May	June	July	August	Lactation Average
HA	7.60^{c}	11.62^{c}	10.67^{c}	11.32^{c}	8.63^{d}	7.76^{b}	9.60^{d}
SA	13.99^{a,b}	13.01^{b,c}	16.34^{a,b}	18.13^{a,b}	14.63^{b,c}	11.52^{a}	14.61^{a,b}
SH	8.12^{c}	11.42^{c}	14.26^{b}	15.45^{b}	13.24^{c}	8.40^{b}	12.29^{c}
BA	16.20^{a}	16.49^{a}	17.48^{a}	20.01^{a}	16.58^{a,b}	13.31^{a}	16.68^{a}
BH	15.34^{a,b}	14.96^{a,b}	17.64^{a}	19.54^{a}	17.70^{a}	13.20^{a}	16.40^{a,b}
JA	15.50^{a,b}	14.71^{a,b,c}	16.18^{a,b}	18.69^{a,b}	14.21^{b,c}	12.58^{a}	15.31^{a,b}
JH	11.92^{b}	13.25^{a,b,c}	16.77^{a,b}	18.52^{a,b}	13.69^{c}	11.69^{a}	14.31^{b,c}
Standard Error	1.19[2]	1.08	.99	1.10	.82	.86	.73[3]
Average	12.67 ± .46	13.64 ± .41	15.62 ± .37	17.38 ± .42	14.10 ± .31	11.21 ± .33	14.17

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

[2] The standard error for SH is 1.37 for March.

[3] The standard error for SH is .78 for the lactation average.

^{a,b,c,d}Means in the same column that do not share at least one superscript in common are significantly different ($P < .05$).

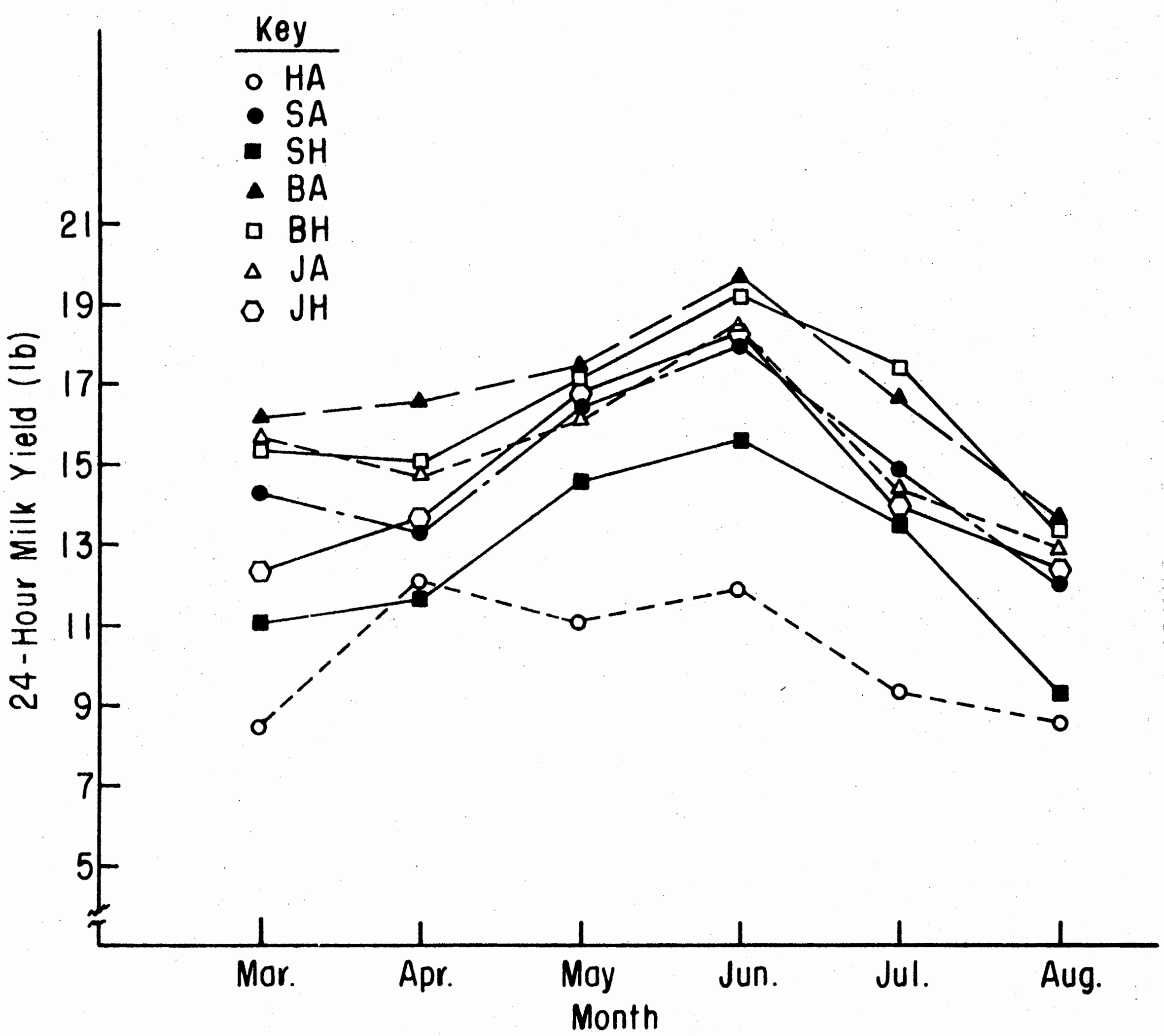

Figure 1. 24-Hour Milk Yield Lactational Curves Over Months

milk production with the cows averaging 11.21 pounds per day. The heat and poorer forage during this period, along with a natural decline of the lactation curve resulted in reduced milk yields.

Generally, the milk yield estimates from this study tend to be higher than those reported by other workers in the literature. McGinty and Frericks (1971) estimated milk yield of 12 Brown Swiss x Hereford cows at an average of 14.6 lb/day of milk. Notter et al. (1978) reported daily milk yields on 59-two-year old crossbred dams as 10.4, 12.6, 9.7, 11.0, 9.3 and 1.0 lb/day for JH, JA, SH, SA, HA and AH, respectively. However, these estimates were obtained by calf nursing techniques rather than machine milkout preceeded by an oxytocin injection. Also, their measurements were not taken at monthly intervals over a six month lactation.

Estimates obtained by Cobb et al. (1978) were obtained on cows from the same crossbred groups and by the same methods. Their estimates were slightly lower for Jersey, Brown Swiss and Simmental crosses (12.8, 12.6 and 11.9 lb/day, respectively) however, their estimate for HA reciprocal cross cows was similar at 10.4 pounds per day.

These estimates are also greater than those reported by Totusek et al. (1973) for 8 Angus, 6 Hereford, 2 Shorthorn, 2 AH, 2 H x Brahman, 2 H x Shorthorn and 2 H x Santa Gertrudis cows that averaged 10.0 to 12.9 pounds per day. Jeffery et al. (1971) presenting data on Angus, Hereford, Galloway, Hybrid and Hereford x Hybrid crosses reported milk yields ranging from 8.4 to 13.4 pounds per day. However, estimates from this study are in agreement with milk production yields reported by Gleddie and Berg (1968) on 13 Hereford, 8 Galloway, 8 Angus, 7 Charolais x Angus and 5 Angus x Galloway cows (range from 8.2 to 18.5

lb/day) and are lower than those observed by Wilson et al. (1969) on Angus x Holstein cows (20.7 lb/day).

Table XX presents means and standard errors for 24-hour butterfat yields of crossbred cows groups. There was considerable variation among crossbred groups and changing of rank each month for butterfat yield. Overall, the cows averaged .52 lb/day of butterfat over their six-month lactations. The Brown Swiss crosses and JA cows were highest in butterfat yields averaging .60 lb/day while JH cows were slightly lower at .57 pounds per day. The SA group was intermediate at .50 lb/day and the SH cows averaged .44 lb/day of butterfat. The cows lowest in milk production, the HA reciprocal cross group, were also the lowest in butterfat yields (.35 lb/day).

Figure 2 depicts butterfat yield lactational curves over six months. Peak butterfat production occurred in May and June with the cows averaging .66 and .68 lb/day, respectively. The HA reciprocal cross cows consistently produced the least amount of butterfat and were followed by SH crossbred cows. There appeared to be interactions present between the other crossbred cow groups and month of lactation. The estimates reported in this study for butterfat yields are also larger than those reported in the literature. Totusek et al. (1973) reported an average of 67.9 lb of fat produced over a 210-day lactation or .32 lb/day on Angus, Hereford, Shorthorn, AH, H x Brahman, H x Shorthorn and H x Santa Gertrudis cows.

Table XXI presents means and standard errors for butterfat percentages. This trait ranked Jersey crosses first (JH at 3.91% and JA at 3.80%) followed by BH and HA cows in an intermediate position at 3.64% butterfat. The Simmental crosses and BA cows were lowest averag-

TABLE XX

MEANS AND STANDARD ERRORS OF TWENTY-FOUR HOUR BUTTERFAT YIELDS OF CROSSBRED COW GROUPS (LB/DAY)

Crossbred Group[1]	March	April	May	June	July	August	Lactation Average
HA	.26[c]	.34[b]	.46[c]	.44[c]	.31[c]	.28[c]	.35[d]
SA	.44[b]	.38[a,b]	.63[b]	.68[a,b]	.50[b]	.39[b]	.50[b,c]
SH	.26[c]	.35[b]	.58[b,c]	.55[b,c]	.49[b]	.28[c]	.44[c]
BA	.53[a,b]	.47[a]	.66[b]	.77[a]	.68[a]	.49[a]	.59[a]
BH	.50[a,b]	.45[a]	.74[a,b]	.77[a]	.68[a]	.49[a]	.61[a]
JA	.63[a]	.45[a]	.69[b]	.77[a]	.51[b]	.46[a,b]	.59[a]
JH	.43[b]	.45[a]	.87[a]	.77[a]	.49[b]	.44[a,b]	.57[a,b]
Standard Error	.05[2]	.04	.06	.05	.05	.03	.03
Average	.44 ± .02	.41 ± .01	.66 ± .02	.68 ± .02	.51 ± .02	.40 ± .01	.52

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

[2]The standard error for SH is .06 for March.

[a,b,c,d]Means in the same column that do not share at least one superscript in common are significantly different (P < .05).

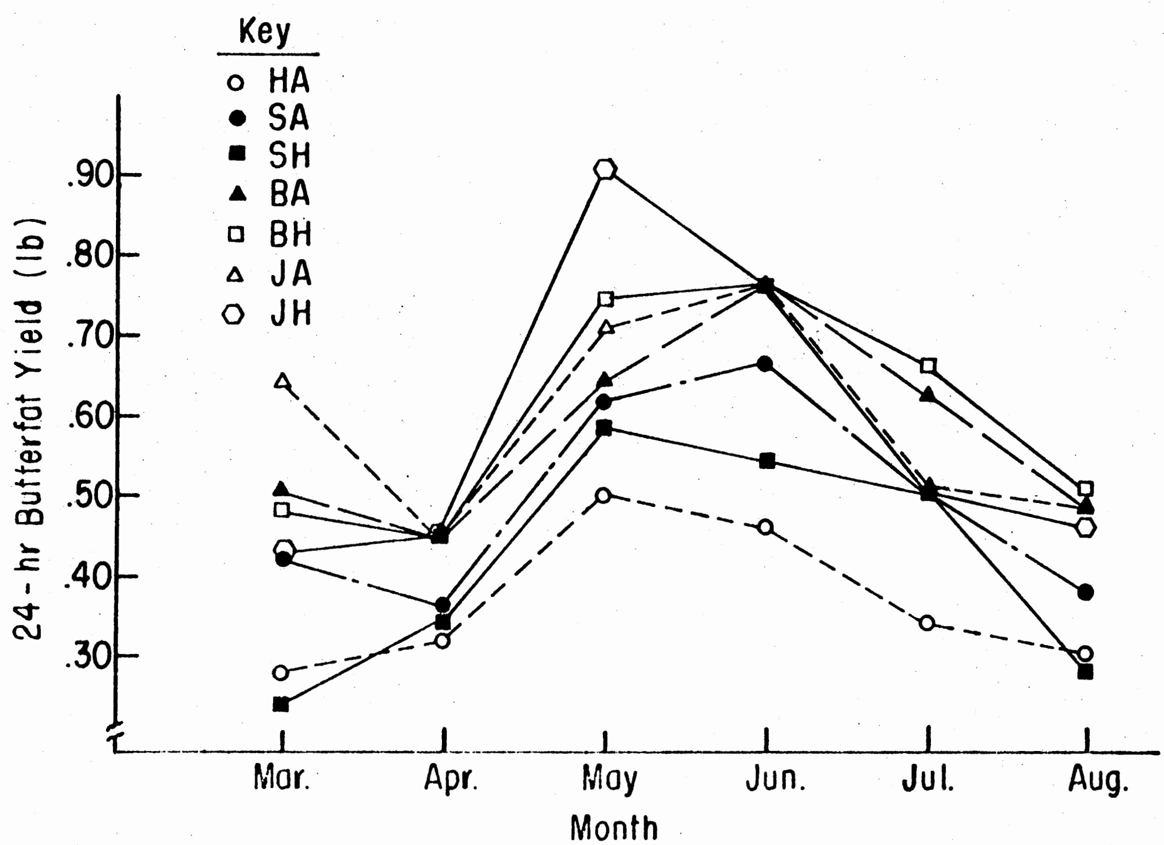

Figure 2. 24-Hour Butterfat Yields Over Months

TABLE XXI

MEANS AND STANDARD ERRORS OF BUTTERFAT PERCENTAGES OF CROSSBRED COW GROUPS

Crossbred Group[1]	March	April	May	June	July[2]	August[2]	Lactation Average
HA	$3.38^{b,c}$	$2.94^{b,c}$	4.30^{a}	3.39^{c}	3.70	3.65	$3.64^{b,c}$
SA	3.09^{c}	$2.90^{b,c}$	3.83^{a}	$3.74^{a,b,c}$	3.78	3.41	3.39^{c}
SH	$3.35^{b,c}$	$3.19^{a,b}$	4.01^{a}	$3.54^{b,c}$	3.64	3.18	3.49^{c}
BA	$3.26^{b,c}$	2.86^{c}	3.76^{a}	$3.85^{a,b,c}$	3.74	3.69	3.53^{c}
BH	$3.24^{b,c}$	$3.01^{b,c}$	4.19^{a}	$3.95^{a,b,c}$	3.78	3.68	$3.64^{b,c}$
JA	4.01^{a}	$3.10^{b,c}$	4.18^{a}	4.19^{a}	3.63	3.70	$3.80^{a,b}$
JH	3.53^{b}	3.41^{a}	5.15^{b}	$4.09^{a,b}$	3.51	3.78	3.91^{a}
Standard Error	.13[3]	.10	.18	.14	.25	.15	.09
Average	3.41 ± .05	3.06 ± .04	4.20 ± .07	3.89 ± .05	3.62 ± .09	3.58 ± .05	3.63

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

[2]Overall f-test not statistically significant ($P < .05$).

[3]The standard error for SH is .15 for March.

[a,b,c,d]Means in the same column that do not share at least one superscript in common are significantly different ($P < .05$).

ing 3.47% butterfat. Overall, the cows produced milk testing 3.63% fat. The highest percents for butterfat were observed in May and June at 4.20% and 3.89%, respectively and there were no crossbred dam group differences in July or August.

The rankings of crossbred cow groups have changed when considering butterfat percent from their rankings for milk and butterfat yields, indicating a low correlation between butterfat percent and yield traits for crossbred range cows. The overall correlation between butterfat percent and milk yield was .05 which is not significantly different from zero ($P < .01$).

These estimates of butterfat percent are higher than those for the crosses reported by Totusek et al. (1973) and Wilson et al. (1969) with estimates of 3.2% and 3.4%, respectively. However, they are lower than those reported by Jeffery et al. (1971) whose purebred and crossbred cattle averaged 3.9% fat. This study is in agreement with data reported by Cobb et al. (1978) for most crosses. Their data reported Brown Swiss, Jersey and HA crosses at 3.6%, 3.7% and 3.6%, respectively, however, the estimate for Simmental crosses was .7% greater (4.1% vs 3.4%).

It seems logical that the milk production of a cow should be influencing her calf's weaning weight and average daily gains from birth to weaning. Table XXII presents the phenotypic correlations between calf performance and milk traits. The overall, simple correlations indicate a moderate correlation between milk yield and calf average daily gain of .71 which drops to .42 when adjusted for crossbred dam differences. The same trends and magnitudes of the correlations were observed for milk yields and calf weaning weight (.69, .42); butterfat yield and calf average daily gain (.69, .50) and butterfat yield and

TABLE XXII

PHENOTYPIC CORRELATIONS BETWEEN CALF PERFORMANCE AND MILK TRAITS

	Calf ADG (lb/Day)	Calf 205-Day Weight (lb)	Calf ADG (lb/Day) ADJ[1]	Calf 205-Day Weight (lb) ADJ[1]
Milk Yield (lb/day)	.71 (.55, .82)[2]	.69 (.52, .81)	.42 (.17, .62)	.42 (.17, .62)
Butterfat Yield (lb/day)	.69 (.53, .81)	.64 (.45, .77)	.50 (.27, .68)	.47 (.23, .66)
Butterfat %	.06 (-.24, .29)	.03 (-.26, .27)	.30 (.03, .53)	.26 (.00, .49)

[1]Correlations pooled over crossbred dam groups.

[2]95% confidence intervals for the correlation by Z - transformation; n = 55.

calf weaning weight (.64, .47). Percent butterfat appeared to have little correlation with calf performance.

The phenotypic correlations between calf performance and milk traits by crossbred cow group are presented in Appendix Table XXXIV. These estimates should be received with caution as they were calculated from very small numbers of observations and consequently have extremely large standard errors.

The correlation adjusted over crossbred dam groups between milk yield and average daily gain is in agreement with those reported by Franke et al. (1975) who estimated a correlation of .45 and .41 for Angus and Hereford cows, respectively. Omar et al. (1977) reported preweaning calf gain was more highly correlated with average daily milk production of the dam in Hereford than Angus cows (.78 vs .44). The correlations for milk yield and calf weaning weight are however, lower than that estimated by Totusek et al. (1973) who found a .88 correlation between the two traits for the various crosses in that study.

Table XXIII presents R^2 values for prediction equations of calf 205-day weaning weight and calf average daily gains based on milk traits. Milk production or butterfat yield account for 40 to 50% of the variation in calf gains and weaning weights. When pooled over crossbred dam groups, the estimates of R^2 drop, ranging from .20 to .30 for those traits. The best model predicting calf weights or average daily gains includes just milk yield or butterfat yield. Combining them or adding butterfat percent does not increase the R^2 values.

These estimates tend to be lower than others reported in the literature, especially if considering the estimates pooled over crossbred dam groups. Neville et al. (1962) reported 66% of the variation in

TABLE XXIII

R^2 VALUES FOR PREDICTION EQUATIONS OF CALF 205-DAY WEANING WEIGHT AND CALF ADG BASED ON MILK TRAITS

Variables in the Model	Prediction Variable			
	Calf 205-Day Weight	Calf ADG	Calf 205-Day WT (ADJ)[1]	Calf ADG (ADJ)[1]
24 Hr. Milk Yield (M24)	.48	.51	.20	.22
% Butterfat (% Fat)	.00	.00	.05	.08
24-Hour Butterfat Yield (F24)	.41	.47	.25	.30
M24[3], % Fat	.48	.51	.20	.22
M24, F24	.48	.51	.25	.30
% Fat, F24	.49	.52	.25	.30
M24, % Fat, F24	.50	.53	.25	.31

[1]Pooled over crossbred dam groups.

calf weights at eight months of age due to milk consumption and Jeffery and Berg (1971) reported 40 to 50% of the variation in weaning weight accounted for by differences in milk yields. Milk yield accounted for 60% of the variation in preweaning average daily gain reported by Jeffery et al. (1971) and 50% reported by Pope et al. (1973).

CHAPTER V

SUMMARY

Production and efficiency traits were studied with 434 two-year-old crossbred cows. The cows were produced in 1973, 1974 and 1975 from the matings of Hereford (H), Angus (A), Simmental (S), Brown Swiss (B) and Jersey (J) bulls to H and A dams. These two-breed cross heifers were mated to Red Poll and Shorthorn bulls to produce their first calves at two-years of age in the spring of 1975, 1976 or 1977. Traits from birth to weaning of 334 three-breed cross calves were also considered in this study. Calves remained on native and bermuda grass pasture at the Lake Carl Blackwell Research Range with their dams until weaning at an average age of 205-days.

Milk production traits of 56 two-year-old crossbred cows were investigated in the summer of 1977. Each cow was milked by a portable vacuum pump milking unit each month for six months. Cows and calves were separated on the average 12 hours before milking. Immediately prior to milking the cows received a 1.5cc injection of syntocin, a synthetic oxytocin, in the jugular vein to stimulate milk letdown. Milk weights were recorded and samples taken for butterfat analysis.

Overall, 84% of the cows exposed to breeding calved the following spring. Jersey crosses, BA and AH groups were all similar in calving percent (averaged 91.5%) followed by BH, SA and HA cows averaging 81.4 percent. The SH had the poorest calving performance with only 57.8% of

the cows calving.

Birth weights varied, with Simmental and Brown Swiss crosses producing the heaviest calves (67.3 lb) while calves from JH and HA reciprocal cross cows averaged 61.6 pounds. The lightest calves were produced by JA cows averaging 57.9 pounds.

The herdsman observed each calf during birth and assigned calving difficulty scores. Overall, Jersey crosses and BA cows had the least calving difficulty with an average of 18.9% difficult births while SH cows experienced the most difficulty (50.0%). Calves from Jersey crosses had the lightest birthweights (59.3 lb) which perhaps accounts for some of their easier calving. However, BA and BH cows which had calves averaging 66.7 and 67.4 lb respectively, at birth experienced 18.2% and 28.2%, respectively, calving difficulty, whereas, AH cows with lighter calves at birth (60.9 lb) had 37.3% calving difficulty. Perhaps the dairy crossbreds have a biological advantage for calving ease over beef crossbreds such as less exterior fat, less muscling or a more flexible pelvic area.

Overall, 76.5% of the cows exposed to breeding weaned a calf, ranging from Jersey crosses (89.8%) to SH cows (53.3%). Brown Swiss crosses, AH and SA cows were intermediate, averaging 76.4%, followed by HA cows at 68.1 percent. Simmental x Hereford cows experienced low reproductive performance throughout this study. Perhaps their difficulty could be attributed to poor condition or light body weight before first breeding. However, as yearling SH heifers were intermediate in weight and similar to BH and HA heifers (averaged 501 lb) while BA and SA groups were heavier (532 and 551 lb, respectively). Jersey crosses and AH heifers had lighter yearling weights (467 and 485 lbs, respectively).

The SH heifers were of average condition (score of 5.0), and all other heifer groups were lower in body condition, ranging from Jersey crosses averaging scores of 3.7 to BA heifers with scores of 4.8 for fat cover. The SH crosses perhaps, just have a slower rate of physiological maturity.

On the average, the dairy crosses were thinner in condition ranging from scores of 3.6 to 4.2 while Simmental crosses, HA and AH cows were of average fat cover (scores from 4.7 to 5.2). Simmental x Angus cows were heaviest as two-year-olds (792 lb) while HA, SH and Brown Swiss crosses averaged 738 pounds. Jersey crosses and AH cows were lightest, averaging 671 pounds. However, summer weight gains were generally uniform over the crossbred cow groups. Simmental crosses, HA, AH, JH and BH were all similar, averaging 92 lb of gain while BA and JA cows were lower at 83 and 68 lbs, respectively, during the six month period.

Simmental, Brown Swiss and Jersey cross cows were all expected to produce more milk than HA and AH crosses, thus raising calves with faster average daily gains and heavier weaning weights. Brown Swiss x Angus cows produced the most milk during their lactation (16.68 lb/day) and did raise calves with the highest average daily gains (1.86 lb/day) and the heaviest weaning weights (448 lb). Jersey crosses, Simmental crosses and BH cows also exceeded HA reciprocal cross cows in milk production (16.40 to 12.29 lb/day vs 9.60 lb/day), calf average daily gains (1.73 vs 1.51 lb/day) and calf 205-day weaning weights (419 vs 369 lb). The phenotype correlations between milk yield and calf average daily gain or weaning weight were .71 and .69, respectively, and both dropped to .42 when adjusting for dam group differences.

Butterfat yields were highest for Brown Swiss crosses and JA cows

(.60 lb/day) followed by JH, SA and SH cows at .57, .50 and .44 lb/day, respectively. The HA reciprocal crosses were lowest in butterfat production, averaging .35 lb/day. Phenotypic correlations between butterfat yield and calf average daily gain or weaning weight were .69 and .64 overall and dropped to .50 and .47, respectively when considering dam group differences.

A critical period in the reproductive management of young cows is the breeding season following birth of their first calf at two-years of age. Overall, 73% of the crossbred cows calving rebred. The JH and JA cows averaged 92.0% and 84.9%, respectively, while SA and HA reciprocal crosses averaged 73.2% and 12.5%, respectively. Poorer rebreeding performances were observed in BA, SH and BH cows averaging 67.4%, 60.0% and 43.6%, respectively.

One of the more important traits to consider is productivity of the breeding herd in terms of pounds of calf weaned per cow exposed. When comparing productivity to the HA reciprocal crosses, Jersey crosses and BA cows were 37.5% more productive or produced 103 more pounds of calf per cow exposed. The SA and BH cows were 11.7% (32 lb) more productive while SH cows were 19.7% (54 lb) lower than HA and AH cows in total productivity.

Efficiency, based on the ratios of calf weaning weight to cow weight or metabolic weight favored Jersey crosses by 18 to 20% over the HA reciprocal cross cows. Brown Swiss crosses were favored by 10 to 15% while Simmental crosses were favored 0 to 5 percent.

The data presented in this study suggest some relatively large differences in two-year-old production among the various crossbred groups. Some of this may be, at least in part, due to differences in rate of physiological development and maturity. Thus, the relative comparisons in productivity and production efficiency may change as the cows mature.

LITERATURE CITED

Baharin, K. and R. G. Beiharz. 1975. Estimation of genetic parameters in beef cattle from records of performance. Australian J. Exp. Agri. Anim. Hus. 15:731.

Baker, R. L. and A. H. Carter. 1976. Influence of breed and crossbreeding on beef cow performance. Ruakura Animal Research Station, Hamilton, New Zealand. Proc. Ruakura Farmers' Conf. 28:39-44.

Barr, A. J. and J. H. Goodnight. 1976. A user's guide to the statistical analysis system. North Carolina State Univ., Raleigh, N.C.

Barr, A. J. and J. H. Goodnight. 1972. A user's guide to the statistical analysis system. North Carolina State Univ., Raleigh, N.C.

Belcher, C. G., A. B. Cobb, M. E. Boyd and R. R. Frahm. 1978. A comparison of calf nursing and machine milkout techniques for estimating milk yield. Proc. Amer. Soc. Anim. Sci. Southern Section Meeting February 5-8, Houston, Texas, p. 18 (Abstr.).

Bowden, D. M. 1977. Growth reproductive performance and feed utilization of F_1 crossbred beef heifers calving as 2-year olds. J. Anim. Sci. 44:872-882.

Cobb, A. B., R. R. Frahm and M. E. Boyd. 1978. Lactational performance of two and three year old crossbred range cows. Proc. Amer. Soc. Anim. Sci. Southern Section Meeting, February 5-8, Houston, Texas, p. 17 (Abstr.).

Cole, L. J. and Ivan Johansson. 1933. The yield and composition of milk from Aberdeen-Angus cows. J. Dairy Sci. 16:565.

Cundiff, L. V. 1970. Experimental results on crossbreeding for beef production. J. Anim. Sci. 30:694.

Cundiff, L. V., K. E. Gregory and R. M. Koch. 1974. Effects of heterosis on reproduction in Hereford, Angus and Shorthorn cattle. J. Anim. Sci. 38:711.

Cundiff, Larry V., Keith E. Gregory, Frank J. Schwulst and Robert M. Koch. 1974. Effects of heterosis on maternal performance and milk production in Hereford, Angus and Shorthorn cattle. J. Anim. Sci. 38:728.

Duetscher, G. H. and J. V. Whiteman. 1971. Productivity as two-year olds of Angus-Holstein crossbreds compared to Angus heifers under range conditions. J. Anim. Sci. 33:337.

Dinkel, C. A. and M. A. Brown. 1978. An evaluation of the ratio of calf weight to cow weight as an indicator of cow efficiency. J. Anim. Sci. 46:614.

Dreury, K. J., C. J. Brown and R. S. Honea. 1959. Relationships among factors associated with mothering ability in beef cattle. J. Anim. Sci. 18:938.

Frahm, R. R., M. E. Boyd and W. E. Sharp. 1976. Performance to weaning of crossbred calves from Hereford cows. Okla. Agr. Exp. Sta. Res. Report MP-96:7.

Frahm, R. R., M. E. Boyd and W. E. Sharp. 1976. Performance to weaning of crossbred calves from Angus cows. Okla. Agr. Exp. Stat. Res. Report MP-96:13.

Franke, D. E., W. C. Burns and M. Koger. 1975. Milk yield and pre-weaning growth in beef cattle. J. Anim. Sci. 41:267 (Abstr.).

Fredeen, H. T., J. E. Lawson, J. A. Newman and G. W. Rahnefeld. 1974. First calf performance of foreign x domestic hybrid heifers. Pub. 1537. Canada Dept. of Agri., Ottawa, Ontario.

Furr, R. D. and A. B. Nelson. 1962. Effect of level of supplemental winter feed on calf weight and on milk production of fall-calving range beef cows. J. Anim. Sci. 23:775.

Gabriel, K. R. 1966. Simultaneous test procedures for multiple comparisons on categorical data. J. Amer. Statist. Ass. 61:1081.

Gifford, W. 1949. Importance of high milk production in beef cows over estimated. J. Anim. Sci. 8:605 (Abstr.).

Gifford, W. 1953. Records of performance for beef cattle in breeding herds, milk production: milk production of dams and growth of calves. Ark. Agr. Exp. Sta. Bul. 531.

Gleddie, V. M. and R. T. Berg. 1968. Milk production in range beef cows and its relationship to calf gains. Can. J. Anim. Sci. 48:323.

Gregory, Keith E., Cecil T. Blunn and Marvel L. Baker. 1950. A study of some of the factors influencing the birth and weaning weights of beef calves. J. Anim. Sci. 9:338.

Holzgraefe, D. P., J. W. Waggoner, Jr., G. G. Cmarik and A. L. Nuemann. 1976. Performance of straightbred and crossbred cows. J. Anim. Sci. 43:219 (Abstr.).

Jeffery, H. B. and R. T. Berg. 1971. Influence of cow size and other factors on weight gain of beef calves to 365 days of age. Can. J. Anim. Sci. 52:11.

Jeffery, H. B. and R. T. Berg. 1971. Evaluation of milk variables as measures of milk effect on preweaning performance of beef cattle. Can. J. Anim. Sci. 51:21.

Jeffery, H. B., R. T. Berg and R. T. Hardin. 1971. Factors influencing milk yield of beef cattle. Can. J. Anim. Sci. 51:551.

Jeffery, H. B., R. T. Berg and R. T. Hardin. 1971. Factors effecting preweaning performance in beef cattle. Can. J. Anim. Sci. 51:561.

Klosterman, Earle W. 1972. Beef cattle size for maximum efficiency. J. Anim. Sci. 34:875.

Kramer, C. Y. 1957. Extension of multiple range tests to group correlated adjusted means. Biometrics 13:13.

Kress, D. D., E. R. Hauser and A. B. Chapman. 1969. Efficiency of production and cow size in beef cattle. J. Anim. Sci. 29:373.

Lamona, D. R., J. H. G. Hoemes and K. P. Haydock. 1969. Estimation of yield and composition of milk produced by grazing beef cows. J. Anim. Sci. 29:606.

Laster, D. B., Gerald M. Smith and Keith E. Gregory. 1976. Characterization of biological type of cattle. IV: Postweaning growth and puberty of heifers. J. Anim. Sci. 43:63-70.

Marshall, D. A., W. R. Parker and C. A. Dinkel. 1976. Factors effecting to weaning in Angus, Charolais and reciprocal cross cows. J. Anim. Sci. 43:1176.

McGinty, D. D. and W. G. Frerichs. 1971. Milk yields and calf performance from crossbred and Hereford cows. J. Anim. Sci. 33:210 (Abstr.).

Melton, A. A., J. K. Riggs, L. A. Nelson and T. C. Cartwright. 1967. Milk production, composition and calf gains of Angus, Charolais and Hereford cows. J. Anim. Sci. 26:804.

Neville, W. E. Jr. 1962. Influence of Dam's milk production and other factors on 120 and 240-day weight of Hereford calves. J. Anim. Sci. 21:315.

Notter, David R., Larry V. Cundiff, Gerald M. Smith, D. B. Laster and Keith E. Gregory. 1978. Characterization of biological types of cattle. VI: Transmitted and maternal effects on birth and survival traits in progeny of young cows. J. Anim. Sci. 46:892.

Notter, David R., Larry V. Cundiff, Gerald M. Smith, D. B. Laster and Keith E. Gregory. 1978. Characterization of biological types of cattle. VII. Milk production in young cows and transmitted and material effects on preweaning growth of progeny. J. Anim. Sci. 46:908.

Omar, M. A., R. R. Frahm, R. H. Mizell and A. B. Cobb. 1977. A comparison of milk production in Angus and Hereford cattle under range conditions. Okla. Agr. Exp. Sta. MP-101 p. 17.

Parker, C. F. 1975. Ohio Agr. Res. and Development Cent. Annu. Rept. to NC-1. Brooking, South Dakota, July 8-9, 1975, p. 78.

Pope, L. S., L. Smithson, Dwight F. Stephens, D. O. Pinney and M. Velasco. 1963. Factors effecting milk production of range beef cows. Okla. Agr. Exp. Sta. Prog. Rpt. 37:69.

Sagekiel, Joe A., G. F. Krause, Bob Sibbit, L. Langford, J. E. Comfort, A. J. Dyer and John F. Lasley. 1969. Dystocia in reciprocally crossed Angus, Hereford and Charolais cattle. J. Anim. Sci. 29:245.

Schwulst, F. J., R. M. Koch, K. E. Gregory, L. V. Cundiff and L. J. Sumption. 1968. Heterosis of milk production in beef cows. J. Anim. Sci. 27:1129 (Abstr.).

Schwulst, F. J., L. J. Sumption, L. A. Swiger and V. H. Cuthaud. 1966. Use of oxytocin for estimating milk production of beef cows. J. Anim. Sci. 25:1045.

Singh, A. R., R. R. Schalles, W. H. Smith and F. B. Kessler. 1970. Cow weight and preweaning performance of calves. J. Anim. Sci. 31:27.

Steel, R. G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., New York.

Totusek, Robert and Dudley Arnett. 1965. Estimations of milk production in beef cows. J. Anim. Sci. 24:906 (Abstr.).

Totusek, Robert, Dudley W. Arnett, G. L. Holland and J. V. Whiteman. 1973. Relation of estimation method, sampling interval and milk composition to milk yield of beef cows and calf gain. J. Anim. Sci. 37:153.

Turner, J. W. and R. P. McDonald. 1969. Mating-type comparisons among crossbred beef cattle for preweaning traits. J. Anim. Sci. 29:389.

U.S.M.A.R.C. 1975. Germ Plasm Evaluation Progress Rep. No. 2, U.S. Dept. Agr. Meat. Anim. Res. Cent., Clay Center, Neb. ARS-NC-22.

U.S.M.A.R.C. 1977. Germ Plasm Evaluation Progress Rep. No. 5, U.S. Dept. Agr. Meat. Anim. Res. Cent., Clay Center, Neb. ARS-NC-55.

Wilton, J. W. 1973. Milk yield measurements on beef cows. Can. J. Anim. Sci. 53:769 (Abstr.).

Willham, R. L. 1972. Beef milk production for maximum efficiency. J. Anim. Sci. 34:864.

Wilson, L. L., J. E. Gillooly, M. C. Rugh, C. E. Thompson and H. R. Purdy. 1969. Effect of energy intake, cow body size and calf sex on composition and yield of milk by Angus-Holstein cows and preweaning growth rate of progeny. J. Anim. Sci. 28:789.

Wistrand, G. C. and J. K. Riggs. 1966. Milk production of Santa Gertrudis cows as measured by calf nursing and machine milkout methods. J. Anim. Sci. 25:263.

APPENDIXES

TABLE XXIV

COW VACCINATION PROGRAM[a]

Time of Vaccination	Vaccination
3 weeks of age	Blackleg Malignant Edema
3 months	Brucellosis
at weaning	IBR BVD Lepto Pasterella PI_3 Blackleg Malignant Edema
prior to first breeding	BVD IBR Lepto Vibrio
prior to second breeding	Lepto Vibrio

[a]All cows under external parasite control throughout their lives.

TABLE XXV

COW REPRODUCTIVE PERFORMANCE BY YEAR

Crossbred Cow Group[1]	No. of Cows Exposed	No. of Cows Calving	Ave. Calving Date	Percent Calving[2]	Percent Live Calves	Percent Calving Difficulty	Percent Weaned[2]	Percent Cows That Rebred[3]
1975								
HA	21	18	2/16	85.7	71.4	22.2	66.7	61.1
AH	22	17	2/27	77.3	72.7	5.9	68.2	70.6
SA	23	16	2/19	69.6	65.2	0.0	65.2	62.5
SH	16	9	3/3	56.3	56.3	55.6	56.3	44.4
BA	16	15	2/15	93.8	87.5	13.3	81.3	46.7
BH	19	14	2/22	73.7	68.4	35.7	68.4	57.1
JA	25	22	2/19	88.0	84.0	4.5	84.0	77.3
JH	19	19	2/12	100.0	100.0	10.5	100.0	89.5
Overall	161	130	2/20	80.7	75.8	15.4	73.9	66.2
1976								
HA	15	14	2/12	93.3	86.7	35.7	80.0	85.7
AH	22	20	2/12	90.9	77.3	65.0	72.7	75.0
SA	25	21	2/12	84.0	80.0	52.4	80.0	66.7
SH	11	7	3/4	63.6	54.5	71.4	54.5	66.7
BA	17	16	2/6	94.1	94.1	18.8	94.1	75.0
BH	18	16	2/13	88.8	88.8	12.5	77.8	18.8
JA	18	18	1/31	100.0	100.0	38.9	100.0	88.8
JH	24	23	2/1	95.8	91.7	21.7	91.7	95.6
Overall	150	135	2/11	90.0	85.3	37.8	82.7	73.2
1977								
HA	11	8	1/31	72.7	63.6	12.5	54.5	75.0
AH	14	14	1/29	100.0	92.9	35.7	92.9	71.4
SA	21	19	2/3	90.5	71.4	47.4	71.4	89.5
SH	18	10	2/14	55.6	55.6	30.0	50.0	70.0
BA	14	13	1/28	92.9	78.6	23.1	78.6	83.3
BH	13	9	2/1	69.2	69.2	44.4	69.2	66.7
JA	16	13	1/30	81.3	81.3	23.1	81.3	92.3
JH	16	14	1/23	87.5	81.3	21.4	81.3	92.9
Overall	123	100	1/31	81.3	74.0	31.0	72.4	81.8

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

[2]Based on number of cows exposed.

[3]Based on number of cows calving.

[4]A score of 3 or more is considered a difficult birth.

TABLE XXVI

MEAN SQUARES FOR CROSSBRED CALF TRAITS - REDUCED MODELS

	Birthweight (lb)		Calving Difficulty		Preweaning ADG		Weaning Conformation		Weaning Condition		Weaning Weight	
Source	df	M.S.	df	M.S.	df	M.S.	df	M.S.	df	M.S.	df	M.S
Year (Y)	2	648.76**	2	4.28	2	.62**	2	9.99**	2	5.50**	2	34363.27**
Sirebreed of Calf (S)							1	17.53**	1	11.88**		
Crossbred Dam Group (C)	7	673.19**	7	3.43**	7	.61**	7	7.48**	7	1.91**	7	28497.66**
Sex of Calf (Sx)	1	1307.68**	1	10.47**	1	.56**	1	2.18	1	7.24**	1	34782.05**
YxC			14	2.55**			14	1.62**	14	.70		
YxSx							2	6.18**	2	1.39		
Error	323	52.33	309	1.12	323	.03	306	.67	306	.55	323	1465.08

*P < .05; **P < .01.

TABLE XXVII

PERFORMANCE TO WEANING OF THREE-BREED CROSS CALVES PRODUCED BY TWO-BREED CROSS COWS BY YEAR[2]

Crossbred Cow Group[1]	No. of Calves	Birth Weight (lb)	Calving Difficulty Score	Preweaning ADG (lb/Day)	Weaning Conformation	Weaning Condition	205-Day Weaning Weight (lb)
1975							
HA	14	64.6	1.69	1.48	12.7	5.2	368
AH	16	58.6	1.67	1.45	12.4	4.6	356
SA	15	67.1	1.41	1.63	12.7	5.2	402
SH	9	65.2	2.50	1.68	12.8	4.8	405
BA	13	64.7	1.63	1.73	12.8	5.1	420
BH	13	67.1	1.91	1.65	12.9	5.2	405
JA	21	56.4	1.31	1.74	11.9	5.7	414
JH	19	60.7	1.46	1.70	11.5	5.3	409
Overall	120	63.0	1.70	1.63	12.5	5.1	397
1976							
HA	12	60.6	1.64	1.43	12.3	4.8	353
AH	16	61.7	3.16	1.50	12.4	4.6	370
SA	20	66.8	2.56	1.71	13.1	5.1	418
SH	6	63.7	2.62	1.65	13.1	4.9	401
BA	16	63.4	1.52	1.86	13.8	5.2	444
BH	14	62.9	1.52	1.70	13.1	4.9	411
JA	18	56.3	2.06	1.67	12.9	4.7	400
JH	22	59.3	1.66	1.69	12.9	4.9	406
Overall	124	61.8	2.09	1.65	13.0	4.9	400
1977							
HA	7	62.0	1.55	1.58	12.6	5.1	386
AH	13	62.0	1.78	1.57	12.6	5.0	384
SA	15	71.4	2.17	1.85	13.6	5.5	451
SH	9	69.8	2.06	1.76	13.0	5.0	431
BA	11	72.6	1.68	1.99	13.7	5.6	480
BH	9	73.4	2.69	1.86	13.4	5.8	454
JA	13	61.5	1.76	1.80	12.6	5.5	430
JH	13	62.3	1.60	1.83	12.5	5.4	438
Overall	90	66.9	1.91	1.78	13.0	5.4	432

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

[2]Means adjusted for all significant main effects and interactions.

TABLE XXVIII

MEAN SQUARES FOR CROSSBRED COW TRAITS - REDUCED MODELS

Source	Cow Spring Weight		Cow Fall Weight		Average Cow Weight		Summer Weight Gain		Spring Condition		Fall Condition		Average Condition	
	df	M.S.	df	M.S.	df	M.S.	df	M.S.	df	M.S.	df	M.S.	df	M.S.
Crossbred Cow Group (C)	7	80676.2**	7	113987.8**	7	98505.7**	7	5395.0**	7	6.88**	7	14.13**	7	8.37**
Year (Y)	--	---	2	44806.9**	2	9500.0*	2	17947.3**	2	22.56**	2	15.78**	2	13.24**
CxY	--	---	--	---	--	---	--	---	--	---	14	2.17**	--	---
Calving Date (CD)	2	13362.1*	--	---	--	---	2	8482.7**	2	.20	2	.16	2	.01
YxCD	4	6448.7*	--	---	4	12138.8**	4	3302.0*	4	4.79**	--	---	4	1.45*
CxCD	--	---	--	---	--	---	--	---	14	.43	--	---	14	.64
Error	319	3177.6	323	4232.2	319	3317.4	317	1327.1	303	.79	307	.81	303	.55

*P < .10; **P < .01.

TABLE XXIX

CROSSBRED COW WEIGHTS BY YEAR[2]

Crossbred Cow Group[1]	No. Lactating Cows	Yearling Wt. (lb)[6]	Spring Wt. (lb)[3]	Fall Wt. (lb)[4]	Average Wt. (lb)[5]	Summer Wt. Gain (lb)
1975						
HA	14	462	679	748	716	71
AH	15	449	649	730	690	77
SA	15	542	769	861	816	93
SH	9	485	694	771	732	74
BA	13	493	693	754	726	65
BH	13	454	697	754	727	58
JA	21	442	661	703	684	42
JH	19	446	640	698	671	63
Overall	119	472	685	752	720	68
1976						
HA	12	513	685	791	728	110
AH	16	498	651	736	682	90
SA	20	557	717	814	757	102
SH	6	514	688	801	745	113
BA	16	530	709	790	738	86
BH	14	539	676	756	706	85
JA	18	460	616	685	637	75
JH	22	477	622	704	649	88
Overall	124	511	671	760	705	94
1977						
HA	7	503	694	816	750	111
AH	13	507	633	756	690	118
SA	15	553	760	866	808	98
SH	9	528	703	834	767	129
BA	11	573	745	849	792	99
BH	9	509	682	805	739	118
JA	13	499	613	708	655	87
JH	13	477	621	726	670	106
Overall	90	519	681	795	734	108

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

[2]Mean adjusted for all significant main effects and interactions.

[3]Weight after first calving.

[4]Weight after first weaning.

[5]Average of Spring and Fall weights.

[6]Based on number of yearling heifers.

TABLE XXX

CROSSBRED COW CONDITION SCORES BY YEAR[2]

Crossbred Cow Group[1]	No. Lactating Cows	Yearling Condition[3]	Spring Condition[3,4]	Fall Condition[3,5]	Average Condition[3,6]
1975					
HA	14	4.1	3.7	5.1	4.4
AH	15	3.5	3.2	5.0	4.1
SA	15	4.2	3.9	5.7	4.8
SH	9	6.1	3.2	4.7	3.9
BA	13	5.7	2.5	4.0	3.4
BH	13	5.5	3.6	4.4	4.0
JA	21	2.9	2.4	3.1	2.7
JH	19	3.3	2.6	3.2	2.8
Overall	119	4.4	3.1	4.4	3.8
1976					
HA	12	4.7	5.4	5.7	5.4
AH	16	4.5	4.1	5.2	4.7
SA	20	4.4	4.3-	5.2	4.8
SH	6	3.9	5.5	5.3	5.4
BA	16	4.1	3.3	4.3	3.9
BH	14	3.8	3.6	4.8	4.2
JA	18	4.1	3.4	4.2	3.6
JH	22	4.0	3.6	4.6	3.8
Overall	124	4.2	4.2	4.9	4.5
1977					
HA	7	5.3	6.0	5.8	5.9
AH	13	4.8	5.0	5.5	5.2
SA	15	4.9	4.8	5.6	5.3
SH	9	4.8	4.9	5.4	5.2
BA	11	4.6	4.1	4.9	4.6
BH	9	4.1	4.5	4.8	4.8
JA	13	4.4	4.2	4.9	4.4
JH	13	3.9	4.4	4.9	4.4
Overall	90	4.6	4.7	5.2	5.0

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

[2]Means adjusted for all significant main effects and interaction.

[3]Condition score equivalents: range from 1 = very thin to 5 = average to 9 = very fat.

[4]Score after first calving.

[5]Score after first weaning.

[6]Average of Spring and Fall scores.

TABLE XXXI

MEAN SQUARES FOR COW EFFICIENCY TRAITS REDUCED MODEL

Source	df	Calf Wn Wt ÷ Cow Weight	Calf Wn Wt ÷ Cow Metabolic Weight
Year (Y)	2	.051**	1.441**
Crossbred Dam Group (C)	7	.087**	1.794**
Sex (Sx)	1	.071**	1.721**
CxSx	7	.010**	.208*
Error	316	.004	.080

*P < .05; **P < .01.

TABLE XXXII

MEASURES OF CROSSBRED COW EFFICIENCY BY YEAR

Crossbred Cow Group[1]	No. of Cows	Calf Wn Wt ÷ Cow Wt		Calf Wn Wt ÷ Cow Metabolic Wt	
		Ratio	% HA[3]	Ratio	% HA[3]
1975					
HA	14	.523		2.70	
			100.0		100.0
AH	16	.510		2.62	
SA	15	.498	96.4	2.65	99.6
SH	9	.552	106.8	2.86	107.5
BA	13	.587	113.6	3.03	113.9
BH	13	.558	108.0	2.90	109.0
JA	21	.614	118.9	3.13	117.7
JH	19	.617	119.5	3.13	117.7
Overall	120	.557		2.88	
1976					
HA	12	.491		2.55	
			100.0		100.0
AH	16	.535		2.74	
SA	20	.548	106.8	2.87	108.5
SH	6	.538	104.9	2.80	105.9
BA	16	.598	116.6	3.12	118.0
BH	14	.573	111.7	2.96	111.9
JA	18	.623	121.4	3.13	118.3
JH	22	.608	118.5	3.09	116.8
Overall	124	.564		2.91	
1977					
HA	7	.525		2.73	
			100.0		100.0
AH	13	.564		2.88	
SA	15	.565	103.8	3.00	107.0
SH	9	.564	103.6	2.96	105.5
BA	11	.610	112.0	3.23	115.2
BH	9	.619	113.7	3.22	114.8
JA	13	.676	124.2	3.39	120.9
JH	13	.662	121.6	3.36	119.8
Overall	90	.598		3.10	

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

[2]Means adjusted for all significant main effects and interactions.

[3]Based on the average of the HA and AH reciprocal crosses = 100 percent.

TABLE XXXIII

MEAN SQUARES FOR MILK TRAITS BY MONTH

Source	March				April				May			
	df	Milk Yield (lb/Day)	Butter-fat Yield (lb/Day)	Butter-fat %	df	Milk Yield (lb/Day)	Butter-fat Yield (lb/Day)	Butter-fat %	df	Milk Yield (lb/Day)	Butter-fat Yield (lb/Day)	Butter-fat %
Crossbred Group (C)	6	101.72**	.148**	.71**	6	27.33*	.024*	.30**	6	48.03**	.135**	1.71**
Milkday (M)	1	98.26**	.166**	.32	1	11.50	.015	.04	1	.43	.055	2.28**
CxM	6	10.72	.009	.13	6	16.40	.007	.27**	6	13.92	.033	.30
Error	40	11.30	.020	.13	42	9.35	.010	.08	42	7.78	.027	.26

Source	June				July				August			
	df	Milk Yield (lb/Day)	Butter-fat Yield (lb/Day)	Butter-fat %	df	Milk Yield (lb/Day)	Butter-fat Yield (lb/Day)	Butter-fat %	df	Milk Yield (lb/Day)	Butter-fat Yield (lb/Day)	Butter-fat %
Crossbred Group (C)	6	74.12**	.143**	.37*	6	66.89**	.108**	.15	6	40.46**	.066**	.36
Milkday (M)	1	1.91	.079	3.11*	1	168.07**	.360**	.46	1	1.15	.031	4.13**
CxM	6	1.79	.011	.29	6	7.18	.010	.37	6	2.57	.004	.10
Error	42	9.76	.021	.15	42	5.41	.019	.50	42	5.97	.009	.17

*P < .05; **P < .01.

TABLE XXXIV

PHENOTYPIC CORRELATIONS BETWEEN CALF PERFORMANCE AND MILK TRAITS WITHIN BREEDGROUPS[2]

Crossbred Group[1]	Milk Yield-Calf ADG	Milk Yield-Calf Wn Wt	Butterfat Yield Calf ADG	Butterfat Yield Calf Wn Wt	Butterfat % Calf ADG	Butterfat % Calf Wn Wt
HA	.70	.59	.49	.38	-.44	-.43
SA	.56	.66	.60	.69	.32	.29
SH	.78	.83	.85	.89	.77	.78
BA	-.23	-.10	-.35	-.35	-.16	-.35
BH	.77	.73	.78	.72	.48	.34
JA	.09	.02	.70	.62	.70	.63
JH	.29	.20	.43	.36	.43	.54

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

[2]n = 8 for each crossbred dam group. S.E. very large.

VITA 2

Carla Gale ~~Belcher~~ Chenette

Candidate for the Degree of

Master of Science

Thesis: PRODUCTIVITY OF TWO-YEAR-OLD CROSSBRED COWS PRODUCING THREE-BREED CROSS CALVES

Major Field: Animal Science

Biographical:

Personal Data: Born in Manchester, Connecticut, September 6, 1954, the daughter of Mr. and Mrs. James E. Chenette; ~~married Danny Ray Belcher, August 6, 1977.~~ divorced

Education: Graduated from Rockville High School, June, 1972; received the Bachelor of Science degree from the University of Connecticut, May, 1977, with a major in Animal Science; completed requirements for the Master of Science degree at Oklahoma State University in December, 1978.

Experience: Worked on dairy and crop farm 1968-1972; Intern at the White House, Washington, D.C., summer, 1974; Graduate Assistant, Department of Animal Science, Oklahoma State University, 1976-1978.

Professional Organizations: American Society of Animal Science, Alpha Zeta, Phi Kappa Phi.