PRODUCTIVITY OF ANGUS-HOLSTEIN CROSSBREDS VERSUS ANGUS HEIFERS UNDER TALL GRASS RANGE CONDITIONS

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CHAPTER I

INTRODUCTION

Beef cattle producers are searching for ways to increase the productivity of their cows in terms of the weaning weight of their calves. They have recognized for many years the importance of milk production in the beef cow and its influence on weaning weight. However, because selection for milk production gives only slow improvement, there has been much interest recently in crossing dairy with beef breeds to increase the milk producing ability of the beef cow. One of the questions arising is whether the dairy crossbred female requires a higher nutrient level than range conditions provide. Few studies have been reported in the literature concerning the productivity of the beef-dairy crossbred female under range conditions.

The purpose of this study was to compare the productivity of two-year-old Angus-Holstein crossbreds with Angus heifers under tall grass range conditions. The period studied was from breeding as yearlings, through calving and rebreeding, to the weaning of the first calf. Characteristics evaluated were milk production, calf growth, rebreeding performance and cow weight change. Also some factors associated with milk production in early lactation were explored, such as stage of lactation and calving date.

CHAPTER II

LITERATURE REVIEW

Little information has been accumulated on the productivity of Angus-Holstein crossbred females. In the few studies reported, relatively small numbers of animals were involved so accurate evaluation of their performance was difficult. More reports are available on the productivity of Angus females, but none compare them adequately with Angus-Holstein females. Therefore, this review will also include selected studies of the productivity of other beef and dairy breeds and their crosses. The term productivity in this review involves milk production, calf growth to weaning and reproductive performance.

Milk Production

Milk production in beef cows is recognized as an important economic trait having a great influence on calf growth and weaning weight. Selection for it has been made more difficult because of the lack of good records. Since records are especially difficult to obtain on cows suckling calves under pasture conditions, there is a shortage of good information on the milk production of beef cows.

Methods

Researchers have used many methods to estimate the milk production of a beef cow and the consumption of her calf. Cole and Johansson

(1933) were able to hand-milk twice daily seven Angus cows which were stall-fed and handled like dairy cows. However, workers needed other methods to get estimates on yields from many animals under pasture conditions. Gifford (1953) estimated milk yield once each month on 47 cows on pasture by hand-milking one-half of the udder while allowing the calf to nurse the other half. The following day the workers reversed the sides to get a better estimate of total yield. Klett, Mason, and Riggs (1965) and Kress, Hauser, and Chapman (1969) also used this procedure.

Anthony et al. (1959) introduced the use of oxytocin to replace the nursing stimulus of the calf. The injection of 2 cc. of this hormone caused the cow to "let down" her milk, thus allowing the use of machine milking. Dawson, Cook, and Knapp (1960) measured milk consumption of the calf by weighing the calf before and immediately after nursing. The authors did this three times per day to get the daily milk consumption. Melton et al. (1967) used the calf nursing method at 12 hour intervals to get the daily consumption. Totusek and Arnett (1965) compared the calf nursing method to that of hand milking one-half the udder and the calf nursing the other one-half. Their data from 24 cows during three lactations showed no significant difference between estimates obtained from the two methods.

Wistrand and Riggs (1966) found no significant difference in estimates from the oxytocin and machine milking method on one-half of the udder and the calf nursing method on the other one-half. Schwulst et al. (1966) used 24 Angus cows to compare the calf nursing method with two variations of the oxytocin method. Their data showed no significant difference between estimates of production from the two methods; however, there was a trend for higher estimates with the oxytocin method.

When comparing the calf nursing method with the method of machine milking of one-half the udder on 21 Angus cows, Serwanja, Welch, and Kidder (1969) found practically no difference. The average milk yield for eight months was 6.7 kilograms per day for the nursing method and 6.6 kilograms per day for the machine milking method. The correlations between the two methods for the eight test period were all highly significant and varied from 0.61 to 0.96.

Lamond, Holmes, and Haydock (1969) from Australia reported on a method of injecting oxytocin into a restrained cow and inserting metal milk catheters into the teats. A funnel collected the milk into a container for weighing. This procedure was done at six hour intervals to estimate the total rate of milk secretion. The authors believed that this method estimated the calf's consumption and was as accurate as the milking machine method.

These reports indicate that several methods can be used with comparable results and the best method would depend on the available facilities, labor supply, and the experience with the techniques.

Milk Production of Different Breeds

The milk production of the different breeds of beef cattle varies considerably. However, there is even more variation between individuals within the same breed, because of the great influence of the environment on this trait.

Cole and Johansson (1933) estimated the average total milk production of seven Angus cows at 3100 pounds per lactation with a range of 884 to 4691 pounds. Using Hereford, Angus, and Shorthorn cows on pasture, Gifford (1953) found an average total milk production of 1498 pounds for a 240 day lactation with a range of 312 to 2458 pounds. He observed that the Shorthorn and Angus cows were slightly higher producers than the Herefords. Dawson et al. (1960) studied 30 beef Shorthorn cows for five years and obtained an average total yield per cow of 4400 pounds for an average lactation of 252 days. A study reported by Neville (1962) on 135 Hereford cows showed that for an eight month lactation the range of milk production was from 400 to 4200 pounds per cow.

Wistrand and Riggs (1966) found that 13 Santa Gertrudis cows in Texas produced during a 205 day period an average total of 2500 and 3600 pounds of milk in 1964 and 1965. In Oklahoma, Furr and Nelson (1964) observed an average total production of 1400 pounds for 18 two-year old fall-calving Hereford heifers on pasture with 2 levels of supplement. Klett et al. (1965) found that 15 Angus cows produced an average of 2040 pounds of milk in an eight month lactation, while 15 Hereford cows produced an average of 1540 pounds. Melton et al. (1967) observed that the average milk production over a 175 day lactation for 15 Angus cows was 1460 pounds, for 15 Charolais cows was 1725 pounds, and for 15 Hereford cows was 1278 pounds.

Cole and Johansson (1948) compared under stall-fed conditions 17 Holstein-Angus crossbred cows with their parental breeds and found that the crossbred's milk production was about midway between the breeds. The Angus cows produced an average of 2906 pounds of milk during 180 days for an average of three lactations, while the Holstein cows produced 5600 pounds and the first cross Holstein-Angus cows produced 4168 pounds. Wilson et al. (1969) reported results from a study of 24 Angus-Holstein four to seven year old cows under drylot conditions. Their average milk production was over 20 pounds per day, which is considerably greater than most of the beef breeds and agrees more closely with the previous crossbred study. These studies indicate that the dairy-beef crossbred may produce more milk under favorable feed conditions.

Yield During Different Stages of Lactation

Milk yield in beef cows during different stages of lactation shows much variation and is not as well understood as the dairy cow's lactation curve. Rook and Campling (1965) reported that the milk production of their Holstein cows peaked at 35 to 40 pounds per day at three to five weeks after calving, then gradually declined to 20 pounds per day at the 35th week of lactation. Cole and Johansson (1948) compared Holstein, Angus, and Holstein-Angus crossbred cows which were stall-fed. They found that the peak production was during the second month of lactation and varied from over 1000 pounds of milk per month for the Holstein to about 300 pounds for the Angus. The Holstein-Angus crosses were intermediate with about 800 pounds per month. The three milk curves were of the same shape, as shown in Figure 1, with the Holstein-Angus cross midway between the Angus and the Holstein. The Angus curve was lower and shorter in length indicating that they did not have the persistency of production as the Holstein or crossbred.

Wilson et al. (1969) noted that the Angus-Holstein crossbred cows had greater persistency than the straightbred beef cows. Cole and Johansson (1933) reported that seven Angus cows milked twice a day had their peak milk production during the first four weeks. Data on 48 Angus cows reported by Drewry, Brown, and Honea (1959) showed their peak production at the third month but much variation existed between animals. Data from Hereford, Angus, and Shorthorn cows reported by Gifford (1953) indicated that maximum production was reached during the first month. Dawson et al. (1960) reported results from a study of 30 beef Shorthorn cows which had their highest milk yield at the end of the second month, but these also showed much variation.

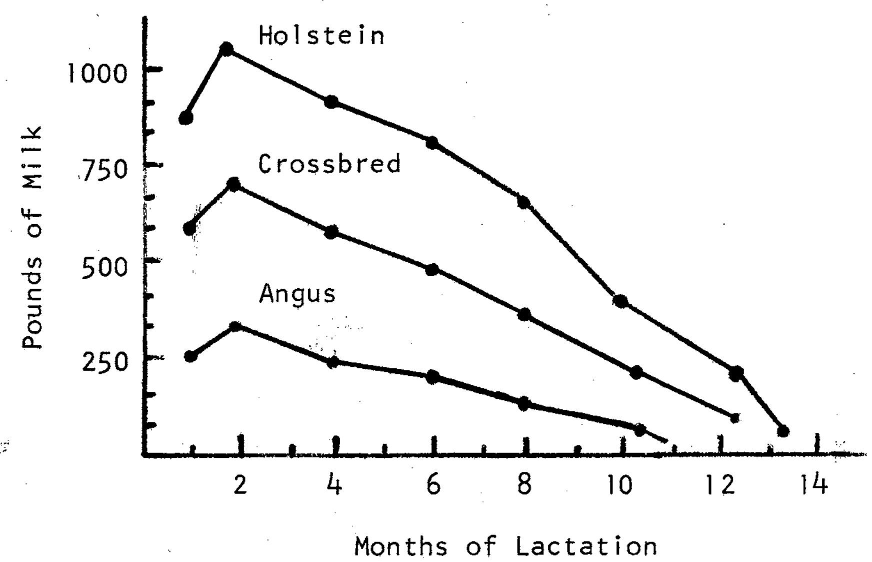

Figure 1. Lactation Curves (Cole and Johansson, 1948)

In 1949, Gifford reported on a study of 57 Hereford cows under pasture conditions which showed a peak production during the first six weeks, then declined gradually toward weaning time. The average daily milk production was 8.6, 7.8, 7.2, 6.0, 6.2, 4.7, 4.7, and 4.2 pounds for the first through eighth month, respectively. The author concluded that the calf was unable to consume all the available milk during the first month causing the cow to decrease her production. Schwulst et al. (1966) studied the production of 24 Angus cows by estimating the total milk production and the total calf consumption during the second, third, and fifth weeks of lactation. Their results agreed with Gifford's (1949) theory. During the second and third weeks of lactation the cow's residual milk was 15 and 11 percent, meaning that the calf did not consume all of the milk. Gleddie and Berg (1968) reported similar results on Hereford, Angus, and Galloway cows. They estimated that the average production of the cows was 2.64 pounds of milk (which was 18 percent) higher than the calves' consumption during the first month of lactation.

If cows produced much excess milk during the first few weeks of lactation, spoiled udders could result. Neville (1962) observed no spoiled udders on seven Hereford cows nursing calves that consumed from 18 to 22 pounds of milk daily during early lactation. Brumby, Walker, and Gallagher (1963) and Christian, Hauser, and Chapman (1965) observed calves that consumed from 16 to over 20 pounds of milk daily during the first few weeks of lactation with no problems of spoiled udders on the cows. These results indicate that the calf is capable of consuming large quantities of milk early in lactation. Therefore, the calf may not be the limiting factor on the early milk production of the cow.

A report from Canada by Gleddie and Berg (1968) indicated that the gradual decline in milk production was linear. Lamond et al. (1969) studied production curves of 60 Hereford cows and observed that 46 cows had a significant linear decline, and 14 had curvilinear and linear components in their production curves.

Milk Composition

Milk composition varies among the different breeds and may contribute to the variation in calf weaning weights. Cole and Johansson (1948) compared the milk composition of 17 Holstein-Angus crossbred cows with each of their parental lines. The butterfat percent was 3.73, 3.51, 4.16 for the Holstein-Angus cross, Holstein, and Angus cows, respectively. This indicated that the Holstein-Angus cow is about midway between the parental breeds in butterfat production. Data from 24 Angus-Holstein crossbred cows studied by Wilson et al. (1969) showed an overall average butterfat percent of 3.43. Melton et al. (1967) reported an average overall butterfat percent of 2.79 from Angus, Charolais, and Hereford cows. The authors found that the Hereford cows had the highest percent total solids in their milk. From 30 beef Shorthorn cows Dawson et al. (1960) observed an average of 3.98 percent butterfat.

Christian et al. (1965) reported a highly significant correlation of 0.40 for percent butterfat to 60 days with weaning weight. This suggests that the calf may need a more concentrated source of energy during early life when its capacity is small. However, no significant correlations for milk composition and average daily gain were found by Klett et al. (1965), Wilson et al. (1969), and Gleddie and Berg (1968).

Factors Affecting Milk Production

The amount of milk produced by beef cows depends on many factors other than genotype, such as: available feed, age of cow, time of calving, and birth weight and sex of calf.

It is well known that adequate nutrition is one of the most important factors influencing milk production. Howes et al. (1958) reported a comparison of levels of 100 percent and 50 percent of the protein requirements in Hereford and Brahman heifers and found that the level of protein had a significant effect on milk yield. Wilson (1964) in New Zealand indicated that under-nutrition immediately before or just after calving influenced milk production. Klett et al. (1965) stated that milk yield curves in beef cows differed from dairy cows because they change according to the feed conditions. Results from Furr and Nelson (1964) supported this by showing that the lowest milk yield for fall-born calves was at the end of the winter season and the highest yield was at the peak of the grazing season.

Neville, Baird and Sell (1960) studied 135 Hereford cows on three levels of nutrition and found that the average daily milk yield was influenced considerably by the level of nutrients. Wilson et al. (1969) compared two groups of 12 Angus-Holstein cows each on an 85 percent and 115 percent of N.R.C. energy requirements. The authors observed a highly significant difference in the average daily milk production between the two energy level groups. The cows on the 115 percent level had an average 12 hour milk yield of 12 pounds compared with 8.7 pounds for the 85 percent level cows. Bond and Wiltbank (1970) imposed 3 levels of energy on 54 Angus heifers and found that the low level caused a 50% reduction of milk compared to the medium level in the first lactation.

It is well established that the younger cows (two to four years old) do not have as great a capacity for producing milk as do the older cows. Gifford (1953) and Dawson et al. (1960) reported that two and three year old cows gave the least milk with a gradual increase to six year old cows. Pearson et al. (1968), Melton et al. (1967), and Drewry et al. (1959) observed that the heavier producing cows were five or more years old. Rollins and Guilbert (1954) and Christian et al. (1965) found that the two year old heifers gave less total milk, but they had a greater persistency in production.

The time of spring calving in relation to onset of grass is known to be a great influence on the lactation curve of the beef cow. In 1964, Wilson reported a significant difference in milk yield between early and late calving cows (average difference in birth date was 52 days). Data from 103 Hereford and Angus cows reported by Nelms and Bogart (1956) showed that calves born early gained 0.20 pounds more daily than the average of the group. They concluded that the time of calving is very important in areas where pasture productivity varies.

Birth weight and sex of calf are associated with the cows milk production, but the extent of this association is not well understood. Schwulst et al. (1966) studied the early lactation of 24 Angus cows and found significant correlations of 0.39 and 0.50 between birth weight and milk consumption at two weeks and average milk consumption to five weeks. Dickey et al. (1970), Melton et al. (1967) and Drewry et al. (1959) indicated a positive correlation between birth weight and cow's milk production. Data from New Zealand by Brumby et al. (1963) showed a non-significant correlation of 0.15 for birth weight and total milk yield to 12 weeks. They found no common factor that increased birth weight and milk yield, but thought that the heavier calf must have a slightly greater appetite. Christian et al. (1965) found a small correlation between birth weight and milk production and concluded that the greater calf weight did not increase milk production.

Cows nursing bull calves gave more milk during early lactation as reported by Melton et al. (1967). Dickey et al. (1970) reported that bull calves consumed significantly more milk than heifers. However, Gleddie and Berg (1968) and Wilson et al. (1969) found no statistically significant difference between milk production of cows nursing male or female calves, probably due to the large variation caused by the different breeds and energy levels involved.

Interest has increased recently on the crossbreeding of beef breeds and beef x dairy breeds to take advantage of the heterotic effects on milk production and weaning weight (Cundiff, 1970). Koch et al. (1968) compared the milk production of 149 crossbred and 101 straightbred Hereford, Angus and Shorthorn cows. Their results showed a heterotic effect of 1.6 percent, 8.5 percent, 6.8 percent and 38.0 percent at two weeks, six weeks, in June, and at about 200 days, respectively. The crossbred calves weighed an average of 27 pounds more at weaning than the straightbred calves. Pahnish et al. (1969) reported results from comparing crosses among Hereford, Angus and Charolais with crosses of Brown Swiss females and beef bulls. The authors found that the Brown Swiss dam's calves produced greater daily gains and heavier weaning weights (approximately 72 pounds greater) than the average beef crossbreds. The Brown Swiss females gave more milk, which probably had the greatest influence on the heavier weights.

Wilson et al. (1969) studied Angus-Holstein crossbred cows and reported that the cows on the adequate level of energy produced calves gaining 2.11 pounds per day over a 123 day period (or 260 pounds). The calves at 200 days of age weighed an average of 450 pounds. This is considerably greater than the Angus and Hereford calf weights and comparable to the Charolais calf weights reported by Melton et al. (1967). These workers reported that over a 175 day period the calf gain for Angus cows was 270 pounds, for Charolais was 352 pounds, and for Hereford was 279 pounds. In summary, these reports indicate that the Angus-Holstein crossbred should produce a larger quantity of milk and raise a heavier calf to weaning than the Angus, but a higher level of nutrition may be necessary for this production.

Calf Growth

Calf growth to weaning has long been used as the best index of the productivity of a beef cow. However, before 1950 practically no information had been accumulated on the main factors that influenced it. Many workers since then have conducted studies on the relationship between milk production and calf growth. Some other factors influencing early growth are birth weight, sex, and cow weight.

Milk Yield on Early Growth

Milk yield in beef cows is known to have much influence on the early growth rate of the calf, but the extent of this association has varied considerably between studies. The earliest calf milk consumption estimates were obtained at two, three, and five weeks after calving by Schwulst et al. (1966) on 24 Angus cows. Their correlations between average daily gain of calf to two weeks and milk consumption at two, three, and five weeks were less than 0.40 and non-significant. However, the correlations between average daily gain from birth to three weeks and from birth to five weeks with total milk consumption to five weeks were highly significant at 0.63 and 0.58. Gifford (1949) and Gleddie and Berg (1968) indicated that the correlation was about 0.60 between average daily gain and average daily milk production during the first month of lactation. The correlation was between 0.71 and 0.75 at eight weeks after calving according to Neville (1962), Gifford (1949), and Gleddie and Berg (1968). Because of the many variables involved and many methods of estimating the association of milk yield and calf growth during the first three months of lactation, the correlations ranged from 0.23 to 0.96 (Serwanja et al., 1969; Melton et al., 1967; Brumby et al., 1963; Klett et al., 1965; and Montsma, 1960).

Milk Yield on Growth to Weaning

The calf's growth is thought to be influenced less by milk consumption from the fourth month to weaning. This seems logical since the calf would be getting more nutrients from other sources such as grass or hay and not be as dependent on the cow's milk. This is supported by evidence reported by Gifford (1949), Gleddie and Riggs (1968), and Brumby et al. (1963). However, Neville (1962) found little decline in correlations during the entire lactation. They varied from 0.74 for the second month to 0.66 for the eighth month of lactation.

When examining the total calf gains or average daily gain to weaning and total milk consumption, the following workers have reported correlations ranging from 0.40 to 0.81 having many different variables such as breeds, ages, feeds, and kinds of correlations: Christian et al. (1965), Furr and Nelson (1964), Melton et al. (1967), Brumby et al. (1963), and Neville (1962). Therefore, the extent that milk production of the beef cow influences calf growth to weaning is still not definite but all agree that it is a very important factor. Neville (1962) found that it was associated with 66 percent of the variation in weaning weights of 135 Hereford calves. While Brumby et al. (1963) reported that it accounted for 50 percent of the variation in calf weaning weights from 25 Angus crossbred cows.

Regressions

Regression coefficients have been calculated by several workers to determine the pounds of milk necessary for a pound of calf gain. Brumby et al. (1963) found that the regression curve for their data on 25 Angus crossbreds was linear starting with a requirement of 9.1 lbs. of milk needed per pound of gain at six weeks and ending with approximately 50 pounds needed at 24 weeks. They noted a definite increase in requirements with increase in age. Kress, Hauser and Chapman (1968) indicated a regression coefficient of 0.74 for weaning weight on milk production. Drewry et al. (1959) observed that it took 12.5, 10.8, and 6.3 pounds of milk for one pound of gain during the first, the third, and the sixth month of lactation on 48 Angus cows. Neville (1962) observed that the conversion rate differed greatly depending on the ration. His data on 135 Herefords showed that the calves nursing cows on the low plane of nutrition were able to convert 12.5 pounds of milk to a pound of gain compared with the high plane needing 23.5 pounds of milk per pound of gain. Melton et al. (1967) observed a low conversion rate on three beef breeds of 5.2 pounds of milk needed per pound of gain. Wistrand and Riggs (1966) observed similar results on Santa Gertrudis cows, and Montsma (1960) noted 8 pounds of milk needed per pound of gain in studies in Ghana. Bond and Wiltbank (1970) reported the lowest conversion rate on Angus heifers of 4.0 kg/kg of gain at 60 days of lactation. Wilson et al. (1969) studies 24 Angus-Holstein cows and reported a higher ratio of milk to average daily gain (11.2:1) than most of the work on beef breeds. This indicated a lower efficiency of the calf to utilize this milk which may have been due to the composition of the milk, the feeding conditions or the method of estimating milk production.

Other Factors Affecting Calf Growth

Numerous workers have studied the effects of calf sex and birth weight on weaning weight. Most researchers have reported that bulls are heavier than steers and steers are heavier than heifers at weaning but the magnitude of the difference varied. This is supported by reports by Neville (1962), England et al. (1961), and Rollins and Guilbert (1954). Although, Nelms and Bogart (1956) found no significant difference between sexes for weaning weight. However, they found that birth weight caused a significant difference on rate of gain. They attributed the difference of weaning weights to heavier calves at birth and faster gaining ability. Their data indicated that an increase of 10 pounds in birth weight caused an increase of 0.115 pounds per day in rate of gain. Gregory, Blunn and Baker (1950) and Christian et al. (1965) reported correlations of 0.60 and 0.62, respectively, between birth weights and weaning weights. Knapp et al. (1942) and Neville (1962) also reported evidence that the heavier calves at birth tended to show a faster rate of gain and heavier weaning weights.

Several workers have shown that cow weight changes during lactation under pasture conditions influence the rate of calf gain and weaning weight. Gregory et al. (1950) reported negative correlations of 0.12 and 0.34 between cow gain and calf gain during the suckling period on herds of 270 and 70 Hereford cows. This indicated that cows which produced the heaviest calves probably sacrificed their body weight to produce more milk. England et al. (1961) found a significant negative correlation between changes in cow weight and calf gain during the lactation period. This trend of the cows losing the most (or gaining the least) during lactation producing the faster gaining calves was also reported by Brinks _et al_. (1962) on mostly mature cows. The cows weighing more before calving tended to produce the heavier calves at weaning according to Knapp _et al_. (1942) and Brinks _et al_. (1962). A study by Vaccaro and Dillard (1966) of different ages of Hereford cows revealed that young cows which weighed the most before calving and gained the most weight during the lactation period produced calves which gained the fastest to 180 days of age. In the older cows the opposite effect was observed which indicated that the higher milk producing cows tended to use nutrients from their body to produce the greater quantity. The authors suggested that the young cows reacted differently because they needed to keep growing during their first lactation so should keep gaining weight.

Twenty-four mature Angus-Holstein cows studies by Wilson _et al_. (1969) showed that they were unable to produce large quantities of milk during the suckling period and maintain their body weight on the recommended energy level for lactating beef cows. This indicated that possibly the higher milk producing dairy-beef crossbred needs a higher level of nutrition to produce this larger quantity of milk. The feed level may be the limiting factor on these crossbreds to produce more milk under range conditions.

Reproductivity Performance

A beef cow must rebreed within a short period (about 80 days) after calving to maintain a calving interval of 365 days or less. Producers cannot afford to sacrifice much breeding efficiency for higher milk production and heavier weaning weights. This rebreeding performance must be acceptable before the dairy x beef crossbreeding programs will be profitable. Studies will be reported which show effects of milk production on rebreeding performance as well as some factors which seem to influence rebreeding.

Effects of High Milk Production

The stress of high milk production is thought to reduce the reproductive efficiency of the cow because of the ability of the udder to function at the expense of other organs. This is illustrated by the fact that the cow can transform body reserves to milk and by the causes of ketosis and milk fever. Boyd (1967) reviewed several studies in dairy cows and found that high milk production does affect significantly the onset of estrus after calving. He stated that with each additional 1000 pounds of milk during the first 120 days of lactation a delay of 1.5 days on first estrus was observed. However, all other evidence indicated no positive relationship between high levels of production and conception rates. Therefore, he concluded that the level of production did not significantly influence reproduction. Results of studies by Gaines (1927), Boyd, Seath and Olds (1954), and Olds and Seath (1953) also supported this conclusion.

Data from 186 Red Danish cows reported by Gaines and Palfrey (1931) showed a small negative correlation between calving interval and yield of milk of present lactation. However, they noted a small positive correlation between calving interval and the yield of milk during the following lactation. Carman (1955) studied 1646 Holstein lactation records and found little relationship of interval to first estrus with present milk production, but did find a positive correlation with the milk production of the previous lactation. These studies point out that the magnitude of this relationship is not great, but show a trend for delayed estrus with high production in dairy cows.

Effects of Feed

The level of nutrition is one of the most important factors influencing the breeding efficiency of a cow, especially the young cow. Smithson *et al*. (1964) reported that a low level of winter feed on bred Hereford yearlings resulted in a marked delay in rebreeding after calving. Turman *et al*. (1964) studied 80 bred Hereford heifers on two levels of winter supplement. The group of heifers that maintained their fall weight through calving returned to heat sooner, bred back earlier, and had a higher conception rate than the group that lost 20 percent of their weight. Three levels of winter feeding were investigated by Turman, Pope and Stephens (1965) on two-year-old Hereford heifers. The results showed that the low and moderate levels caused the calving date to be five weeks and three weeks later, respectively, than the high level. However, half of this delay was due to late breeding as yearlings and half from the longer interval after calving to rebreeding. The authors concluded that adequate nutrition was just as critical for the lactating two-year-old as for the open yearling.

Wiltbank *et al*. (1962) reported data from 88 mature Hereford cows with half fed a high level of energy (9 pounds of TDN per head per day) and half fed a low level of energy (4.5 pounds of TDN per head per day). After calving each level was split into a high level (16 pounds) and a low level (8 pounds). The results showed that the percent of cows pregnant on the high-high and low-high levels were 95 percent compared to 77 percent for the high-low and 20 percent for the low-low levels. This indicates that the level of energy after calving is very important for good rebreeding. A more extensive study on the levels of energy after calving with restricted intake before calving was conducted by Wiltbank et al. (1964). The authors found that mature cows fed 100 percent of requirements after calving showed a significant shorter interval to first estrus than the groups fed more or less. Lower levels of energy caused a delay in first estrus but by increasing this level to 150 percent, this brought all cows in heat and a much higher percent pregnant.

A recent study by Dunn et al. (1969) on 240 Hereford and Angus bred yearling heifers indicated that the pregnancy rate is directly related to the post-calving energy level. The authors found a significant difference between the percent pregnant at 120 days post-calving, which was 87 percent, 72 percent, and 64 percent for the high energy level, the moderate level, and the low level, respectively. The highest pregnancy rate was on the cows that were gaining rapidly during the breeding season. They observed a significant difference (25 percent to 6 percent) between the onset of estrus to 40 days post partum for the cows on a high level of energy before calving and the low energy level group. These reports show the importance of adequate nutrition for good reproductive performance.

Effects of Heterosis

Heterosis resulting from crossbreeding has also been found to influence the fertility of the beef cow. Wiltbank et al. (1967) conducted a study on the effects of heterosis on reproductive performance of three breeds of beef cows to produce straightbred or crossbred calves. The authors found that the cows bred to produce crossbred calves conceived six percent better at first service and had four percent more calves alive at two weeks after calving and at weaning. They concluded that there was a slight advantage for the cows producing crossbred calves.

Turner, Farthing and Robertson (1968) studied 645 straightbred and 700 crossbred Angus, Hereford, Brahman and Brangus cows. Their results indicated a 9.6 percent ($P < .01$) advantage in calf crop for the crossbred cows. Schilling and England (1968) also concluded that the crossbred cows excelled the straightbred in calf production. Their results showed a heterotic advantage of 16.6 percent in favor of the crossbred cows in calving rate. Therefore, heterosis for calving rate may also be a factor in the overall advantage of crossing dairy x beef breeds.

This review indicates that the dairy x beef crossbred can have a greater productivity than the beef cow if adequate feed conditions are available. They have the ability to produce larger quantities of milk and heavier calves at weaning, but these products are very dependent on the feed level. For the crossbred to maintain her weight and rebreed after calving, a higher level of nutrition may be necessary than for the beef cow. No data are available on how the crossbreds will perform under range conditions, so this study will provide information in this area.

CHAPTER III

MATERIALS AND METHODS

This study was superimposed on a progeny test breeding study which permitted only 40 Angus-Holstein crossbreds and 42 Angus heifers to be used as the experimental animals in this study. The crossbred heifer calves, originating from dairy herds in which Angus bulls had been used, were purchased from various sources in Kansas and Oklahoma. They were brought to the Lake Carl Blackwell range near Stillwater, Oklahoma in the early spring of 1968 from the Fort Reno Research Station where they had been accumulated. The Angus heifer calves were selected in the fall of 1967 as replacements from the progeny test herd at the Blackwell range. Twenty-one of the Angus heifers had been weaned at 4 months of age to initiate another study while the other 21 had been weaned at the regular time of about 7 months.

These 82 yearling heifers had to be randomly allotted within breed to ten different sire groups for breeding because of their involvement with the breeding study at the Blackwell range. Approximately 22 mature cows and 8 yearling heifers were exposed for breeding to one registered Angus yearling bull in pastures of 150 to 200 acres in size. The breeding season extended from May 1 to August 1, 1968.

Management

The heifers were managed under range conditions at all times with only native grass, mainly bluestem, during the grazing season. Winter supplemental feed consisted of 2 lb./hd./day of cottonseed meal cubes starting about the middle of November to the middle of April, and 5 lb./hd./day of prairie hay from January 1 to April 15. The cubes were fed daily but the hay was fed only 3 times per week. A mixture of 2 parts salt to 1 part bone meal was available free choice. Water from ponds, windmills, and Lake Carl Blackwell was available in the various pastures.

Calving season began about February 1 and extended to the middle of April. During this time the heifers were grouped in two 100-acre pastures and observed twice daily. Heifers were given assistance during calving if the herdman felt that progress was unsatisfactory. The calves were weighed, tattooed and ear tagged within 12 hours after birth and all data recorded including calving losses and difficulties. All retained placentas were physically removed after 3 to 4 days. The calves remained with their dams on pasture with no creep feed. They were vaccinated for blackleg and malignant edema and surgically castrated during the last week in April. Spraying or dusting to control flies was practiced every 3 to 4 weeks during the summer.

Milk Production

To facilitate the handling of the heifers and their calves for estimating milk production, the heifers were grouped into two pastures according to their calving date. All heifers calving during any one week were grouped together into what was called a "week group." The odd week groups (1,3,5,7,9) were in one pasture and the even week groups (2,4,6,8,10) were in the other. Milk production estimates on a week group began when the average age of the calves in that group was 2 weeks old. This meant that the variation in age of calves was 11 to 17 days for a week group at the time of the first milk production estimate. An estimate was made at 2 week intervals thereafter until breeding began May 1. This gave a total of 6 milk production estimates on the heifers which calved early while 3 very late calving heifers had only one estimate. After May 1 a fixed group of only 13 cows was randomly selected (due to the lack of facilities) from each breed for testing every four weeks until weaning in September. This procedure gave a total of eleven estimates for some of the early calving cows. Sex of calf was not stratified in the randomization procedure, but the number in each sex was quite similar between breeds.

Milk production was estimated by the calf nursing method. This method involved weighing the calf before and immediately after nursing and the difference in the weight was used as the amount of milk consumed. The following procedure was used at each test period. The cows and calves to be tested were brought into the corral shortly after noon on the day before the test. The calves were separated from the cows and each pair was identified by writing the same number with a grease pencil on their sides. This identification made nursing in groups of 4 to 5 pairs quite satisfactory. The calves were allowed to nurse out their mothers that evening which put all the cows on the same basis for the test. The next morning (12 hours after evening nursing) the first milk estimate was taken by individually weighing each calf before and immediately after nursing which gave an estimate of the milk consumed. The nursing period lasted from 15 to 30 minutes depending on the age. For calves less than 6 weeks old another estimate was taken six hours later to allow them to nurse more often. An estimate of milk consumption was taken on all calves at 12 hours after the first estimate, and the total of the 2 (or 3) estimates was used as the daily milk consumption. It was assumed that the calves consumed most of the available milk so this was used as an estimate of the cow's daily milk production. However, it should be pointed out that these estimates were low because of some urination and defecation of the calves while nursing, but efforts were made to minimize these losses. The cows were allowed to graze in 10-20 acre traps in which water was available during milk test days except during the actual test. Calves were held in drylot, and water was made available only during hot weather.

The estimated total milk yield for each cow to May 1 was determined by using each milk test estimate as the average daily milk (ADM) yield for the short period in which it was centered. This total milk yield and the total number of lactation days to May 1 for each cow were each pooled within breed to obtain the ADM yield for each breed which was multiplied by 60 to give the 60 day adjusted total milk yield.. The 140 day and 200 day adjusted total milk yields were calculated in the same manner.

Calf Growth

Calf growth was evaluated by using the first calf weight on the morning of each milk test to calculate the gain since the last test day. In this way the calves' growth could be compared at intervals during the lactation period. Sex differences between breeds within week groups were not evaluated because of the small numbers involved and the confounding with birth weight and calving date. The calves were weaned, weighed and given conformation and condition scores on

September 18 at an average age of 205 days. All weaning weights were adjusted to a 205-day basis as follows: actual weaning weight minus birth weight divided by actual age in days times 205 plus birth weight. The scores were given individually by three experienced graders from a scale ranging from 1-17 with 17 corresponding to the top fancy grade.

Rebreeding

Rebreeding performance was evaluated from records on breeding dates, conception rates and 1970 spring calving dates. Since the cows were still in the progeny test herd, they were again randomly allotted within breed to ten sire groups for the rebreeding period between May 1 and August 1, 1969. During this time the herdsmen made daily observations to record breeding dates. Sixty days after the breeding season (in October) the cows were pregnancy checked by rectal palpation to determine conception rate. To confirm the pregnancy check and to calculate calving interval, the 1970 calving dates were obtained. Calving interval was determined by calculating the days between the first and second calving dates.

Cow Weights and Scores

Individual cow weights and condition scores were taken at each milk test period to determine the pattern of the progressive changes. The condition scores were based on a scale of 1 to 9, with 1 being very thin and 9 being very fat. Weights and condition scores were also taken on the heifers before breeding as yearlings, before calving as two-year-olds, before rebreeding and after weaning their first calf.

Statistical Analysis

Due to the small and unequal numbers of animals involved in this study, the data were analyzed by calculating means ($\bar{x}$), standard deviations (s) and standard errors ($s_{\bar{x}}$) for making preliminary comparisons between week groups. All analyses were performed as outlined by Steel and Torrie (1960). When the analysis allowed pooling of data within breed over week groups, or between breeds, a pooled variance (s_p^2) was calculated by adding the corrected sums of squares and dividing by the pooled degrees of freedom using the formula:

$$\frac{\sum x_1^2 + \sum x_2^2 \; . \; . \; . \; . \; . \; + \sum x_{10}^2}{(n_1-1) + (n_2-1) \; . \; . \; . \; . \; . \; + (n_{10}-1)} = s_p^2$$

where,

s_p^2 is the pooled variance for all groups

$\sum x^2_{1...10}$ is the corrected sums of squares for each group

$n_{1...10}$ is the number of observations in each group.

Standard errors were put on the means of pooled data by using:

$$s_{\bar{x}} = \sqrt{\frac{s_p^2}{n}}$$

where,

$s_{\bar{x}}$ is the standard error of the mean

s_p^2 is the pooled variance for the groups

n is the number of observations in that particular mean.

The major analysis used for testing for significant differences between means of milk production, calf gain and cow weight change was the Student's t test. Because the calculations for this test depend on whether the two populations have a common variance, a test for equality of variance was done by determining F from the formula:

$$F = \frac{\text{the larger } s^2}{\text{the smaller } s^2}$$

The computations also varied depending on equal or unequal size samples.

With common variances and unequal sample numbers the pooled variance was obtained and inserted into the following formula to calculate $s_{\bar{d}}$ which was divided into $\bar{d}$ for the t test.

$$s_{\bar{d}} = \sqrt{s_p^2 \left(\frac{n_1 + n_2}{n_1 n_2}\right)}$$

where,

$s_{\bar{d}}$ is the standard error of the difference

s_p^2 is the pooled variance

n_1 is the number of observations in group one

n_2 is the number of observations in group two.

The degrees of freedom were $(n_1 - 1) + (n_2 - 1)$. With common variances and equal numbers the formula was:

$$s_{\bar{d}} = \sqrt{\frac{2s_p^2}{n}}$$

where,

$s_{\bar{d}}$ is the standard error of the difference

s_p^2 is the pooled variance

n is the common sample size.

When it was found that the variances differed significantly, the $s_{\bar{d}}$ used in the t test was obtained by:

$$s_{\bar{d}} = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

where,

$s_{\bar{d}}$ is the standard error of the difference

s_1^2 is the variance of group one

s_2^2 is the variance of group two

n_1 is the number of observations in group one

n_2 is the number of observations in group two.

The degrees of freedom used was the average (n - 1) from the two samples. Chi square analysis was used to test for significant differences between breeds in the breeding data.

Linear and partial correlations were obtained to determine the association between the major traits studied, such as milk production, calf gain and cow weight change. Regression coefficients were calculated to determine the relationship between milk yield and calf gain during the early and the entire lactation. The assumptions throughout these analyses were that the traits were normally distributed and the samples were somewhat realistic of the population.

CHAPTER IV

RESULTS AND DISCUSSION

Calving Data

A summary of the breeding and calving results for comparing the crossbreds with the Angus is presented in Table 1. Nine of the crossbred heifers were pregnant when purchased and were excluded leaving 31 for this study. One Angus heifer broke a leg and was slaughtered leaving 41 Angus. Eighty-seven percent of the crossbreds and 83 percent of the Angus heifers conceived as yearlings. The crossbreds were larger and possibly older (since purchased with no birth dates) at breeding which probably caused part of this difference. The average weight of the crossbreds before breeding was 607 pounds compared to 553 pounds for the Angus heifers.

The larger crossbred heifers had 7.9 percent more live calves than the Angus, and only 11 percent of the crossbreds needed assistance at calving compared to 23.5 percent for the Angus. One Angus heifer died during calving before assistance could be given. These differences are probably due to the larger size of the crossbreds at calving since they averaged 110 pounds more in weight (869 to 759) before calving than the Angus. The crossbreds were also less fleshy in condition with a score of 3.26 compared to 4.30 for the Angus. This higher liveability of the crossbreds' calves may have been partially due to a heterotic effect according to Turner et al. (1968) and Schilling and England (1968).

TABLE 1

SUMMARY OF BREEDING AND CALVING RESULTS OF CROSSBRED AND ANGUS HEIFERS

	Heifers	Open		Calves Lost		Calving Assistance		Calf Sex		Calving Date[1]		Calf Birth Weight (lbs.)	
Breed	No.	No.	%	No.	%	No.	%	M	F	Range	Avg.	Mean	SE
Crossbred	31	4	12.9	3	11.1	3	11.1	13	14	35-111	(Feb. 24) 55	67.0*	1.99
Angus	41	7	17.1	6	17.6	8	23.5	15	19	31-118	(Mar. 6) 65	51.7*	.73

[1]Day of year

*Values significantly different ($P < .01$)

Retained placentas were not a problem in either group with only two in the crossbreds and one in the Angus. It was observed that the crossbred heifers had much larger udders before calving and some even exhibited edema in front of the udder. Some quarters became quite large and were not suckled for the first three to four days after calving, but no spoiled quarters developed.

The average calving date for the crossbreds was February 24 compared to March 6 for the Angus; however, the range in dates was quite large for both groups. This means that the crossbreds conceived 10 days earlier (assuming equal length of gestation). As shown in Table I, the average calf birth weight of the crossbreds was significantly heavier ($P < .01$) than the Angus by over 15 pounds. The larger size of the crossbred cows probably caused part of this difference. This was a very sizeable difference and gave these calves a great advantage from the start which persisted to weaning. This greater size probably enabled the calves to consume the larger quantity of milk which the crossbreds produced.

Milk Production

The results of the milk production data analysis will be presented in chronological order. First, the milk yield of the "week groups" will be compared during early lactation, then through the summer period, to finally the complete lactation curves. Data on the effects of stage of lactation and calving date will be discussed in relation to milk yield.

Early Lactation

The average daily milk production of the week groups at 2 week intervals for early lactation is given in Tables II and III. The staggered entries are due to the progressively later calving dates from group 1 to 11 and the corresponding date of first milk test. Two tables are shown because of different test dates, since the even numbered groups were tested one week and the odd numbered the next week. In each table a comparison of the two breeds within each week group can be made for each test date. Also the changes within week group within breed as lactation progresses can be seen by comparing the production between test dates. When making comparisons throughout these data, it should be remembered that only small numbers of animals were involved.

Tests for equality of variance revealed a significant difference ($P < .01$) in variances between breeds in the first test period, but not in the other test periods. The crossbreds had the larger variation in milk yield. The average daily milk yield (ADM) for the crossbreds in group 1 varied from 18 pounds in the middle of February to 12.3 pounds in the middle of April. The crossbreds had significantly higher ADM than the Angus at all test periods to May 1 with the differences varying from 9.0 to 3.4 pounds. In group 2 (Table III) the differences between breeds were smaller and fewer animals were involved. In later groups the numbers of animals became progressively smaller and more variable making comparisons more difficult. In Figure 2, group 1 is used as an example of the ADM curves for the crossbreds and Angus from the second week of lactation to weaning. Note that after April 29 only a random half of the animals were tested every four weeks (designated by break in curve lines). The fluctuation of the crossbreds was large with a downward trend in March and the first part of April to a peak in late April and a decline to weaning in September. However, there was much varia-

TABLE II

MEANS AND STANDARD ERRORS OF DAILY MILK PRODUCTION IN WEEK GROUPS AT TWO WEEK INTERVALS

		Test Dates - Weight in Lbs.											
		Feb 18		Mar 4		Mar 18		Apr 1		Apr 15		Apr 29	
Week Groups	No.	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
#1													
Crossbred	4	18.1	± 2.36	13.8	± 1.22	14.9	± 1.15	12.4	± 1.06	12.3	± 1.51	15.6	± 1.97
Angus	6	9.1	± .73	9.2	± .96	9.5	± .46	9.0	± .45	8.8	± .41	9.4	± .49
Diff.		9.0*		4.6*		5.4**		3.4*		3.5*		6.2**	
#3													
Crossbred	3			14.3	± .38	11.9	± 1.61	11.8	± 1.09	11.8	± 1.24	14.8	± .67
Angus	2			8.6	± 1.37	7.6	± 2.12	8.9	± 2.38	7.8	± 3.00	9.1	± 3.13
Diff.				5.7		4.3		2.9		4.0		5.7	
#5													
Crossbred	3					11.8	± .71	14.8	± 1.14	17.3	± .93	16.2	± .80
Angus	3					8.5	± .52	10.8	± .79	12.6	± .44	11.9	± .83
Diff.						3.3		4.0*		4.7**		4.3*	
#7													
Crossbred	2							14.4	± .12	14.9	± 1.63	17.4	± .12
Angus	2							10.4	± 1.37	11.3	± .50	13.1	± 1.63
Diff.								4.0		3.6		4.3	
#9													
Crossbred	None									--	--	--	--
Angus	2									15.1	± 1.12	14.4	± .12
#11													
Holstein	1											14.0	
Angus	1											21.0	

*(P < .05)

**(P < .01)

TABLE III

MEANS AND STANDARD ERRORS OF DAILY MILK PRODUCTION IN WEEK GROUPS AT TWO WEEK INTERVALS

		Test Dates - Weight in Lbs.									
		Feb 25		Mar 11		Mar 25		Apr 8		Apr 22	
Week Groups	No.	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
#2											
Crossbred	5	16.0	± 1.59	12.3	± 1.65	11.0	± 1.19	13.5	± .30	16.3	± .91
Angus	2	10.3	± 1.25	10.5	± 0	9.1	± .12	8.9	± .12	10.4	± .88
Diff.		5.7*		1.8		1.8		4.6**		5.9*	
#4											
Crossbred	3			12.3	± 2.58	13.0	± .76	14.0	± 1.09	16.6	± .17
Angus	1			6.3		11.3		9.0		11.5	
Diff.				6.0		1.7		5.0		5.1	
#6											
Crossbred	1					15.8		14.5		17.8	
Angus	3					8.7	± .88	10.2	± 1.75	11.3	± 1.38
Diff.						7.1		4.3		6.5	
#8											
Crossbred	None							--	--	--	--
Angus	3							9.3	± 1.75	13.6	± 1.02
#10											
Crossbred	None									--	
Angus	1									6.5	

*(P < .05)

**(P < .01)

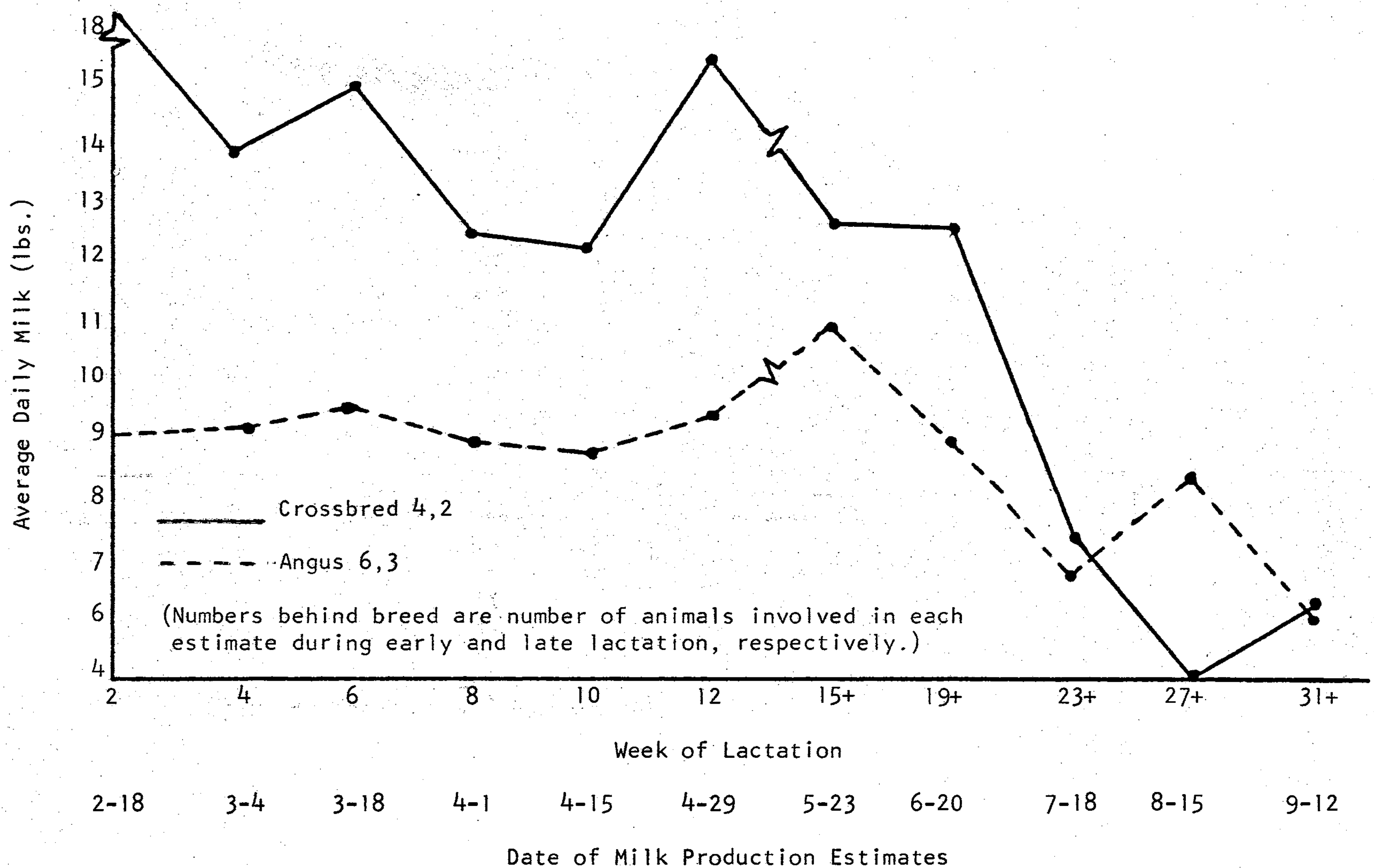

Figure 2. Average Daily Milk Production for Group 1 During Entire Lactation

tion within the group so values were not significantly different. The Angus were more stable during early lactation with a small peak in May followed by a gradual decline. The lactation curves from the second week to May 1 for groups 2 to 5 are presented graphically in Figure 3 and illustrate the large variation between groups within breed. It appears from these curves that the lowest milk production in the crossbreds is during the middle to the last of March after which there is a rapid increase to the last of April and into May. There appears to be a trend for the crossbreds calving in early February to start with a high milk production which declines into March, while the heifers calving in March start lower and continue to increase into May. More discussion on effect of calving date will follow in this section.

Table IV gives the results of the t test on differences between ADM of each breed for each milk test disregarding week groups (age of calves). The crossbreds produced significantly more milk at all but two test periods with a range of 3 to 9 pounds more than the Angus. These means are shown graphically in Figure 4.

The crossbreds produced over 250 pounds more milk on the average during the first 60 days of lactation (over 4 pounds/day) than the Angus (Table V). As would be expected, the cows calving in February gave more total milk to May 1, but the March calving cows gave a higher average daily milk yield to May 1.

Summer and Total Milk Production

Milk production estimates from May 1 to weaning in September were taken on only 13 randomly selected cows from each breed. The results of the pooled within breed ADM for each month is given in Table VI. The

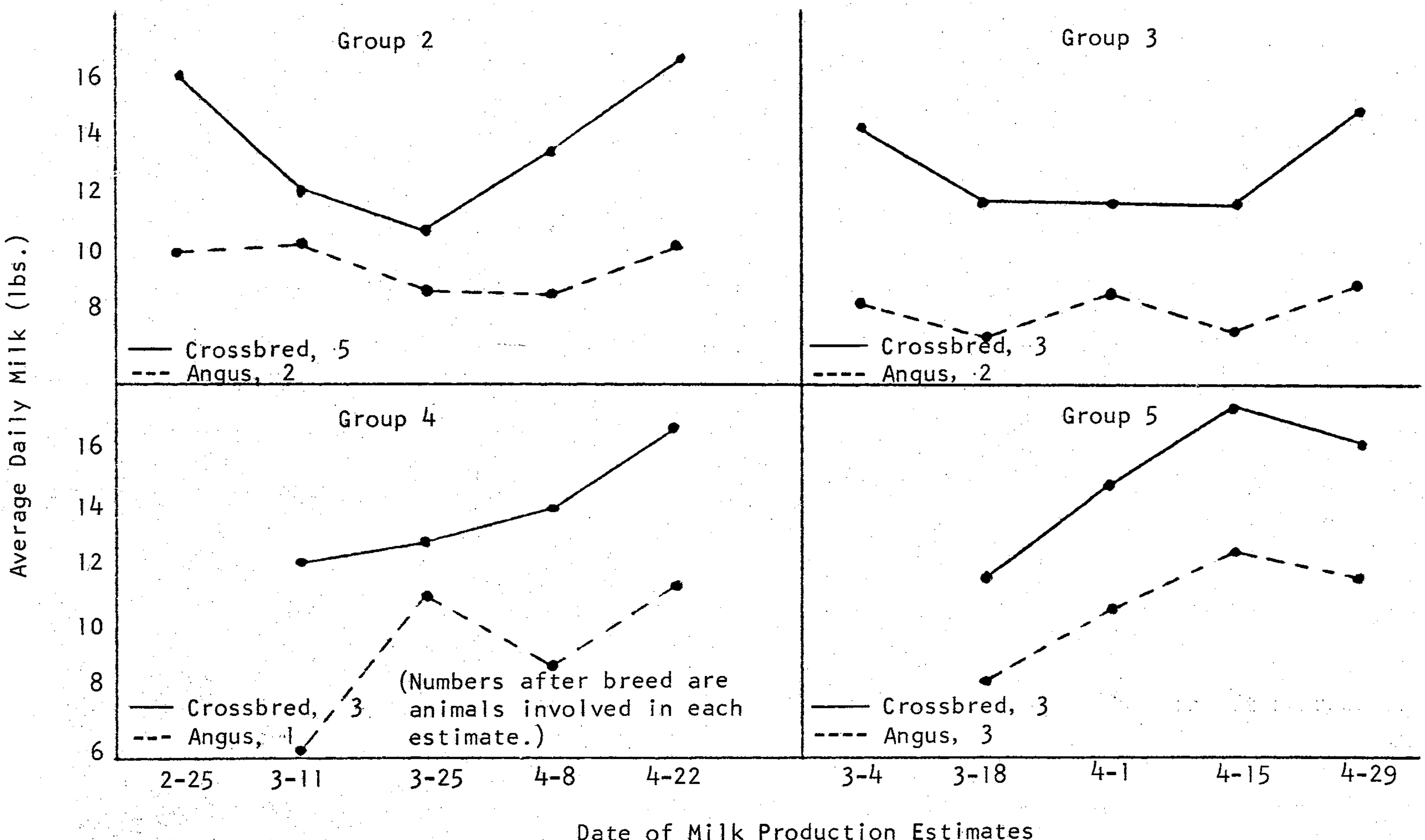

Figure 3. Average Daily Milk Production for Groups 2-5 in Early Lactation

TABLE IV

MEANS AND STANDARD ERRORS OF DAILY MILK PRODUCTION WITHIN BREED FOR EACH TEST PERIOD[1]

Test Period	Crossbreds			Angus			Diff.
	No.	Mean	SE	No.	Mean	SE	
Feb 18	4	18.1 ±	2.36	6	9.1 ±	.73	9.0**
Feb 25	5	16.0 ±	1.59	2	10.3 ±	1.25	5.7
Mar 4	7	14.0 ±	.67	8	9.1 ±	.75	4.9**
Mar 11	8	12.3 ±	1.30	3	9.1 ±	1.42	3.2
Mar 18	10	13.1 ±	.79	11	8.9 ±	.45	4.2**
Mar 25	9	12.2 ±	.87	6	9.3 ±	.57	2.9*
Apr 1	12	13.2 ±	.60	13	9.6 ±	.46	3.6**
Apr 8	9	13.8 ±	.37	9	9.4 ±	.74	4.4**
Apr 15	12	13.8 ±	.91	15	10.6 ±	.75	3.2**
Apr 22	9	16.5 ±	.51	10	11.4 ±	.81	5.1**
Apr 29	13	15.7 ±	.64	16	11.7 ±	.88	4.0**

[1]Milk in lbs.

*(P < .05)

**(P < .01)

TABLE V

TOTAL ADJUSTED MILK YIELD AND YIELD PER DAY TO MAY 1

Breed	No.	Ave. 60 Day Adj. Yield (lbs.)	Ave. Yield/Day (lbs.)
Crossbred	22	837.6	13.96
Angus	26	585.0	9.75
Diff.		252.6	4.21

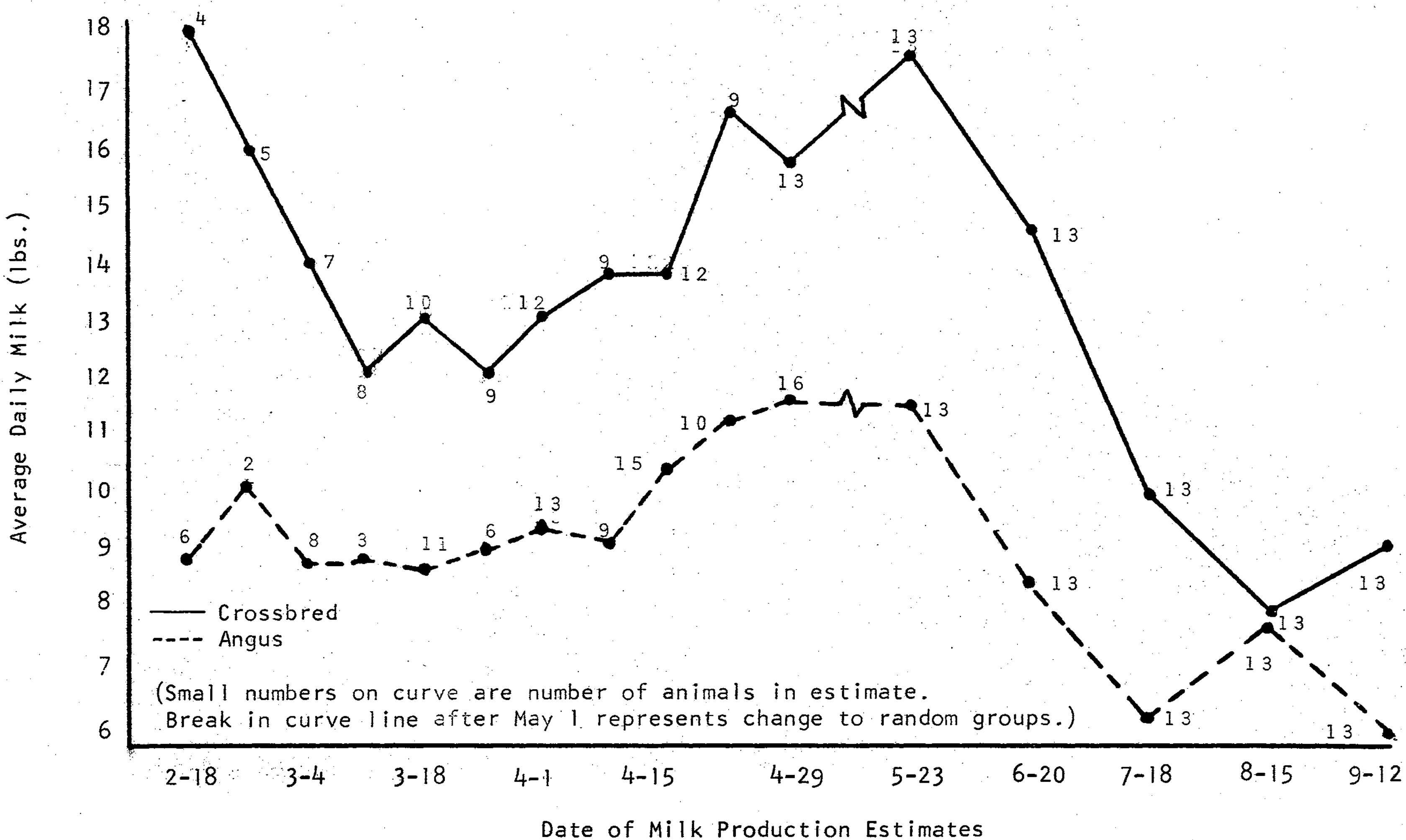

Figure 4. Average Daily Milk Production for Entire Lactation

TABLE VI

POOLED MEANS AND STANDARD ERRORS OF DAILY MILK PRODUCTION DURING SUMMER[1]

Breed	No.	May		June		July		Aug.		Sept.	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Crossbred	13	17.46 ±	1.19	14.65 ±	1.05	10.20 ±	.72	8.27 ±	.99	9.41 ±	1.01
Angus	13	11.65 ±	.88	8.73 ±	.41	6.53 ±	.46	8.04 ±	.34	6.26 ±	.25
Diff.		5.81**		5.92**		3.67**		.23		3.15*	

[1]Milk in lbs.

*(P < .05)

**(P < .01)

crossbreds produced 17.5 pounds of milk in May compared to 11.7 pounds for the Angus giving a highly significant difference ($P < .01$) of 5.8 pounds. Milk production of both breeds decreased to weaning but the crossbreds produced significantly more in all except the August test period (when poor estimates were obtained due to rain). These means are presented graphically in Figure 4.

The total milk yield adjusted for lactation length and yield per day for the summer and the entire lactation period is given in Table VII. The crossbreds produced an average of 483 pounds more milk during the 140 day summer period or 3.45 pounds/day more than the Angus. This 3.45 pound advantage for the crossbreds was only slightly lower than the margin during the first 60 days of lactation (4.21 pounds). The crossbreds excelled the Angus in total milk production for an adjusted 200 day lactation by a highly significant ($P < .01$) 752 pounds or 3.76 pounds/day. It is believed these values are a valid estimate of the original groups.

TABLE VII

TOTAL ADJUSTED MILK YIELD AND YIELD PER DAY FOR SUMMER AND ENTIRE LACTATION[1]

		May 1 to Weaning		Entire Lactation	
Breed	No.	Ave. 140 Day Adj. Yield	Ave. Yield Per Day	Ave. 200 Day Adj. Yield	Ave. Yield Per Day
Crossbred	13	1674.4	11.96	2502.0	12.51
Angus	13	1191.4	8.51	1750.0	8.75
Diff.		483.0	3.45	752.0*	3.76*

[1]Milk in lbs.

*($P < .01$)

The total 200 day adjusted yield for the crossbreds of 2502 pounds is considerably lower than the 4168 pounds reported by Cole and Johansson (1948) from crossbreds over 180 day period because these crossbreds were fed like dairy cattle on a high nutritional plane. It is also lower than the results of Wilson et al. (1969) who reported an average yield of over 20 pounds/day for 24 four to seven-year-old Angus-Holstein crossbreds in drylot. In making these comparisons one must remember that the crossbreds on pasture would not be expected to have as high a production as those in drylot or stall-fed. This production does agree with the Santa Gertrudis (Wistrand and Riggs, 1966), and is higher than most reports on straight beef breeds. The 1750 pounds produced by the Angus agrees quite closely with the Angus production reported by Klett et al. (1965) and Melton et al. (1967). It is higher than the results of Gifford (1953) and the 1400 pounds for 2-year-old Herefords reported by Furr and Nelson (1964).

Figure 4 graphically presents the average daily milk production for the two breeds from 16 test periods during the entire lactation period. These estimates were made from all cows tested on each test day. They include cows at different stages of lactation within breed so are confounded with calving date, but they are comparable between breeds. These milk curves support the previously mentioned trend for the crossbreds to begin high in February, decrease to the middle of March, gradually increase to a peak in late April and May, and then decline to September. The Angus curve is similar but appears more stable at first with a rise in April and May and then a decline to weaning. It is believed that these curves reflect the level of nutrition, especially in the crossbreds, since the lowest level would probably be in March before spring grass and the highest during the peak grazing season in May. This conclusion supports the findings of Neville et al. (1960), Wilson (1964), Furr and Nelson (1964), Klett et al. (1965), Wilson et al. (1969) and Bond and Wiltbank (1970) that the nutritive level has a great influence on milk production.

Effects of Stage of Lactation and Calving Date

Stage of lactation and calving date are known to influence milk production but it is difficult to determine to what extent, since they are confounded with each other and with pasture conditions. The effects of stage of lactation for these data are given in Table VIII which has the ADM yield pooled within breed at two week intervals with calf age or stage of lactation about the same for each week. It should be noted that the early calving cows are involved in all stages and make up the latter stages entirely. The results show highly significant differences ($P < .001$) between breeds for each week of lactation but no significant difference within breed. Figure 5 shows these means in graphic form and the upward trend for the crossbreds after the second month of lactation and a slight downward trend for the Angus. However, nutrition level is still confounded with these data. Peak of lactation has been reported between the first and third months by many workers and this wide variation is probably due to the influence of nutrition. Trends in their data would indicate that the crossbreds have a peak at 2 weeks and then another at the height of the grazing season. The Angus may peak at 4 weeks but grazing conditions have a great influence on this.

The time of calving in relation to the feed or pasture conditions is one of the most important factors which influence milk production.

TABLE VIII

MEANS AND STANDARD ERRORS OF MILK PRODUCTION POOLED WITHIN BREED AT TWO WEEK INTERVALS DURING EARLY LACTATION[1]

Weeks	Crossbreds No.	Crossbreds Mean	Crossbreds SE	Angus No.	Angus Mean	Angus SE	Diff.
2	22	14.8 ±	.72	26	9.9 ±	.37	4.9**
4	21	13.3 ±	.60	24	10.7 ±	.43	2.6**
6	21	14.1 ±	.47	19	10.5 ±	.39	3.6**
8	18	13.9 ±	.35	15	10.0 ±	.46	3.9**
10	12	14.6 ±	.66	12	9.5 ±	.59	5.1**
12	5	16.0 ±	1.76	7	9.6 ±	.45	6.4**

[1]Milk in lbs.
**($P < .001$)

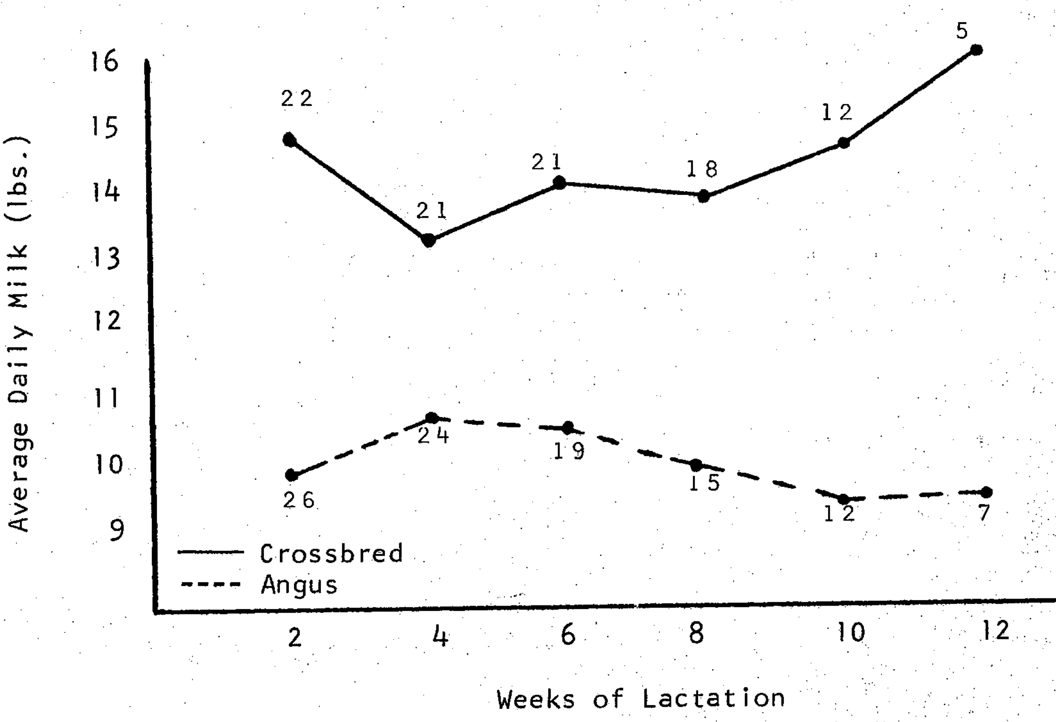

Figure 5. Means of Daily Milk Production Pooled Within Breeds at 2 Week Intervals During Early Lactation

Figure 6 shows the average daily milk yield at the second, fourth, and sixth week of lactation for each week group on their respective test dates. For instance, the curves in the second week of lactation represent the ADM for each week group on their first milk test date. The estimates in these curves are not significantly different within breed but do show a trend, especially in the crossbreds during the second week, of a progressive decrease in yield from the cows calving early in February to the cows calving early in March (group 1 to 5). The later calving cows show more variation but also a trend upward. In comparing the 3 different weeks of lactation, the lowest yield seems to be during March and the first part of April regardless of the week of lactation. This would indicate that the yield is low during this period no matter when the cow calves. Thus, it appears that cows calving in February will decrease during March and cows calving in March will start with a lower yield but will continue to increase in production to a peak in May. Therefore, the cows that calve during March have a higher ADM yield to May 1 which aids their calves in faster growth.

Calf Growth

The results of the calf growth data are presented in a similar manner to the milk production data by starting with birth weights and continuing to weaning weights.

Birth Weights

As previously mentioned, the crossbreds had a significantly heavier ($P < .01$) average calf birth weight. The variance of the crossbred calves' birth weight was also significantly larger ($P < .05$) than the

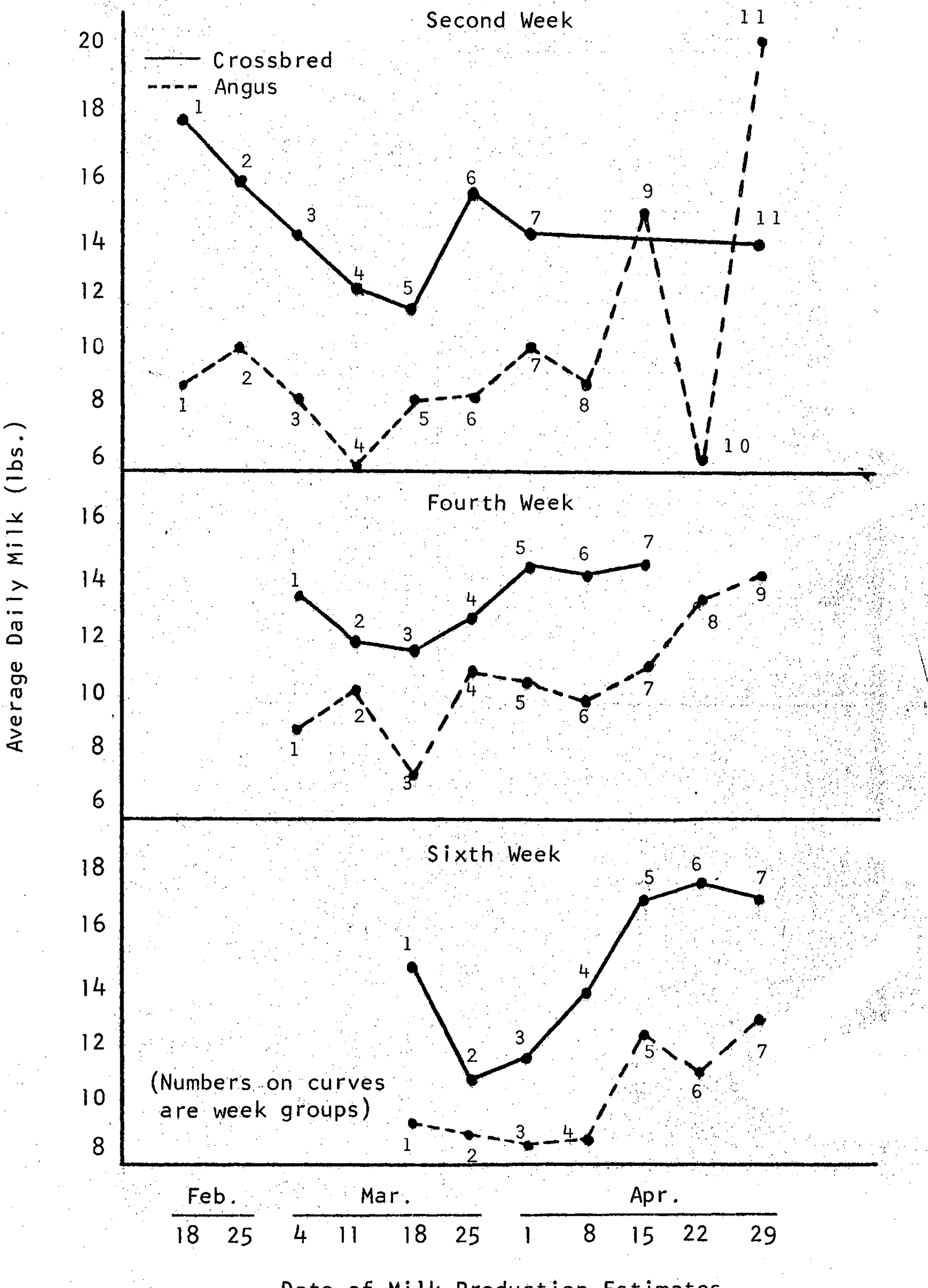

Figure 6. Average Daily Milk Production at 2, 4, and 6 Weeks of Lactation for Each Test Period

variance of the Angus calves' birth weight. These data were also examined for the effects of calving date on birth weights and the results are shown in Figure 7. No significant differences were found within breed between week groups, but there may be a slight trend for the later born calves to weigh more. The regression coefficients indicate that it required a 10.4 day increase in calving date to increase birth weight 1 pound for the crossbreds but 25.4 days were needed in the Angus.

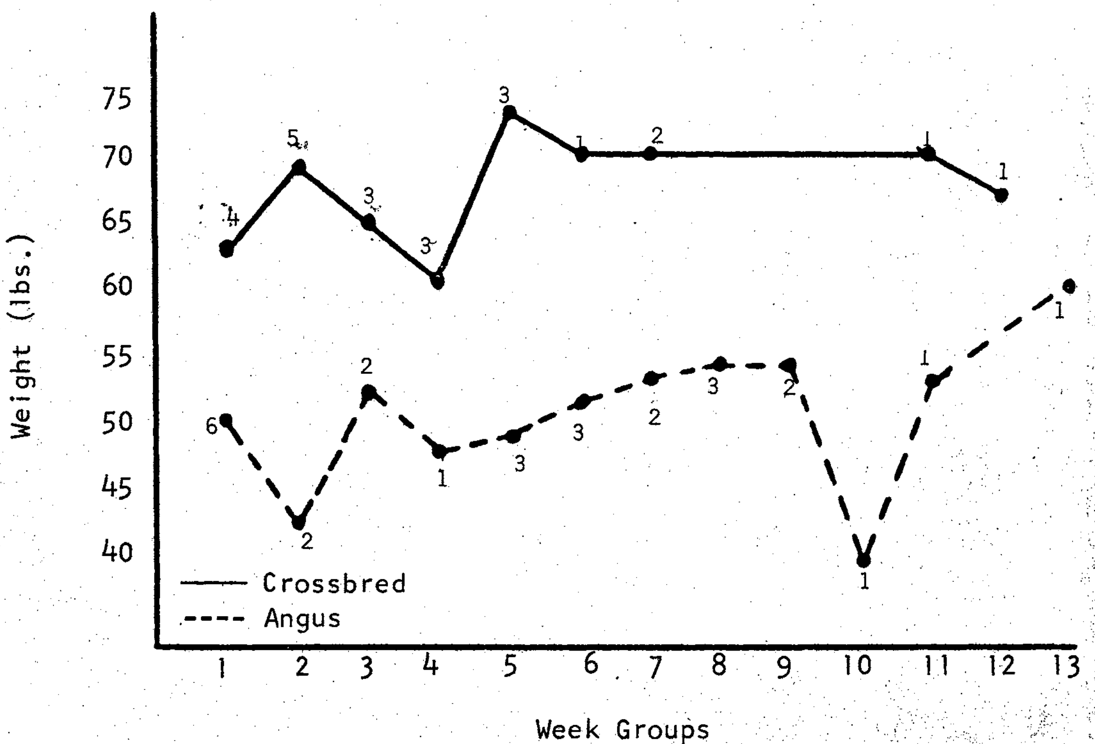

Figure 7. Average Birth Weights of Week Groups

Early Calf Growth

A summary of calf weights for the week groups at 2 week intervals (corresponding to the ADM yields) is given in Tables IX and X. The backcross calves (3/4 Angus-1/4 Holstein) weighed more at all test periods. Weights in groups 1 and 5 between breeds were significantly different and the differences in all groups increased as the calves got older. The faster growth of the backcross calves was probably due to the larger quantity of milk consumed and the genetic potential for more rapid growth. Figure 8 shows the growth rate of group 1 calves which are used as an example to illustrate the increase in the differences between the breeds from birth to weaning. Because of the large difference in birth weights between breeds, the average daily gain (ADG) curves are meaningful (Figure 9). These curves show the low rate of gain between the middle of March and April with a rapid rise to a peak in May and June and then a decline, which parallels the overall milk production curve.

Table XI presents the average calf weights pooled within breed at 2 week intervals (from 2 to 12 weeks) with all calves being approximately the same age within week. These means were calculated in the same manner as the means in Table VIII. The backcross calves weighed significantly more at all weeks and increased the 15 pound difference at birth to 29.4 pounds at 12 weeks of age. This increase in weight is shown graphically in Figure 10. The ADG calculated between these week intervals show that the growth rate of the backcrosses was faster between all weeks except between 6-8 weeks of age (Figure 11). The largest difference in ADG was 0.34 pounds per day at 4-6 weeks, and the smallest was 0.02 pounds per day in favor of the Angus calves at 6-8 weeks. The ADG

TABLE IX

MEANS AND STANDARD ERRORS OF CALF WEIGHTS IN WEEK GROUPS AT TWO WEEK INTERVALS

		Test Dates - Weight in Lbs.					
		Feb 18	Mar 4	Mar 18	Apr 1	Apr 15	Apr 29
Week Groups	No.	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
#1							
Crossbred	4	86.8 ± 6.40	110.9 ± 9.02	123.3 ± 8.04	135.6 ± 7.49	150.4 ± 8.34	169.2 ± 8.39
Angus	6	69.3 ± 4.04	86.0 ± 3.69	96.2 ± 3.55	110.0 ± 3.11	121.5 ± 3.16	140.0 ± 3.78
Diff.		17.5*	24.9*	27.1**	25.6**	28.9**	29.2**
#3							
Crossbred	3		85.6 ± 7.61	97.8 ± 6.37	107.8 ± 5.55	122.1 ± 6.60	140.7 ± 9.10
Angus	2		66.3 ± .75	76.6 ± 2.62	87.8 ± 1.75	100.3 ± .25	113.0 ± .65
Diff.			19.3	21.2	20.0	21.8	27.7
#5							
Crossbred	3			76.4 ± 3.05	97.7 ± 2.79	115.1 ± 3.69	132.6 ± 5.20
Angus	3			65.3 ± 2.46	80.6 ± 2.02	93.8 ± 1.49	108.1 ± 2.89
Diff.				11.1*	17.1**	21.4**	24.5*
#7							
Crossbred	2				88.9 ± .37	108.6 ± 2.12	130.0 ± 2.50
Angus	2				73.0 ± 3.25	89.8 ± 5.03	102.3 ± 4.75
Diff.					15.9	18.8	27.7
#9							
Crossbred	None					-- --	-- --
Angus	2					82.3 ± .25	97.0 ± 2.00
#11							
Crossbred	1						91.0
Angus	1						90.3

*(P < .05)
**(P < .01)

TABLE X

MEANS AND STANDARD ERRORS OF CALF WEIGHTS IN WEEK GROUPS AT TWO WEEK INTERVALS

Week Groups	No.	Test Dates - Weight in Lbs.									
		Feb 25		Mar 11		Mar 25		Apr 8		Apr 22	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
#2											
Crossbred	5	93.8	± 3.93	112.8	± 5.65	132.3	± 7.18	144.6	± 7.93	169.2	± 9.77
Angus	2	70.5	± 5.00	87.9	± 6.38	104.8	± 3.50	114.8	± 3.75	137.1	± 3.63
Diff.		23.3*		24.9		27.5		29.8		32.1	
#4											
Crossbred	3			82.9	± 3.61	100.4	± 4.23	114.8	± 2.24	137.9	± 5.03
Angus	1			61.0		67.3		81.8		101.8	
Diff.				21.9		33.1		33.0		36.1	
#6											
Crossbred	1					94.5		114.5		137.5	
Angus	3					66.3	± 8.86	81.6	± 10.13	100.0	± 10.99
Diff.						28.2		32.9		37.5	
#8											
Crossbred	None							--	--	--	--
Angus	3							72.0	± 9.10	89.0	± 10.84
#10											
Crossbred	None									--	
Angus	1									52.0	

*($P < .05$)

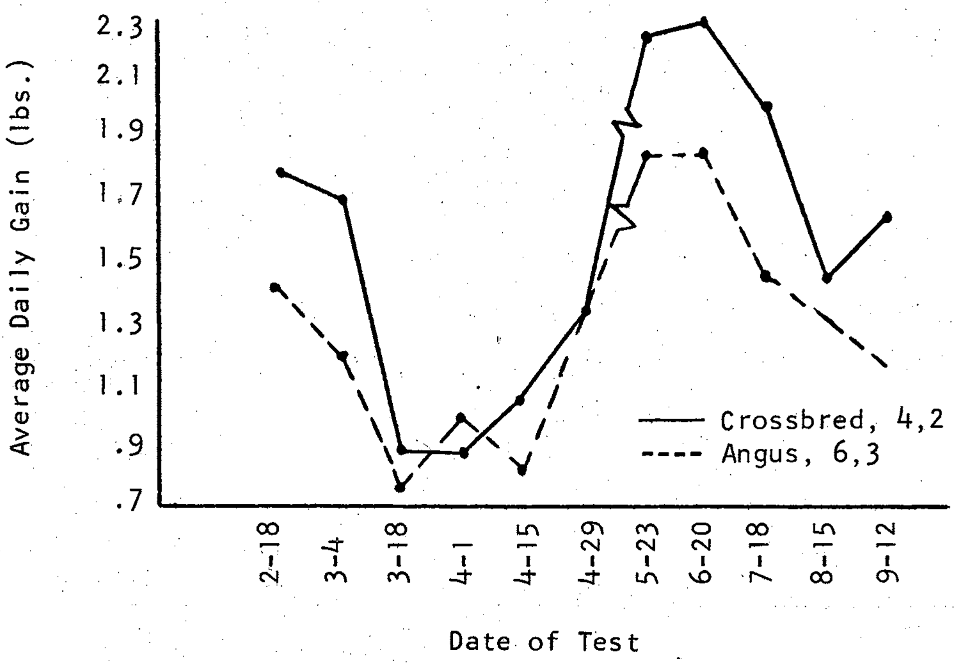

Figure 9. Average Daily Gain of Calves in Group 1 From Birth to Weaning

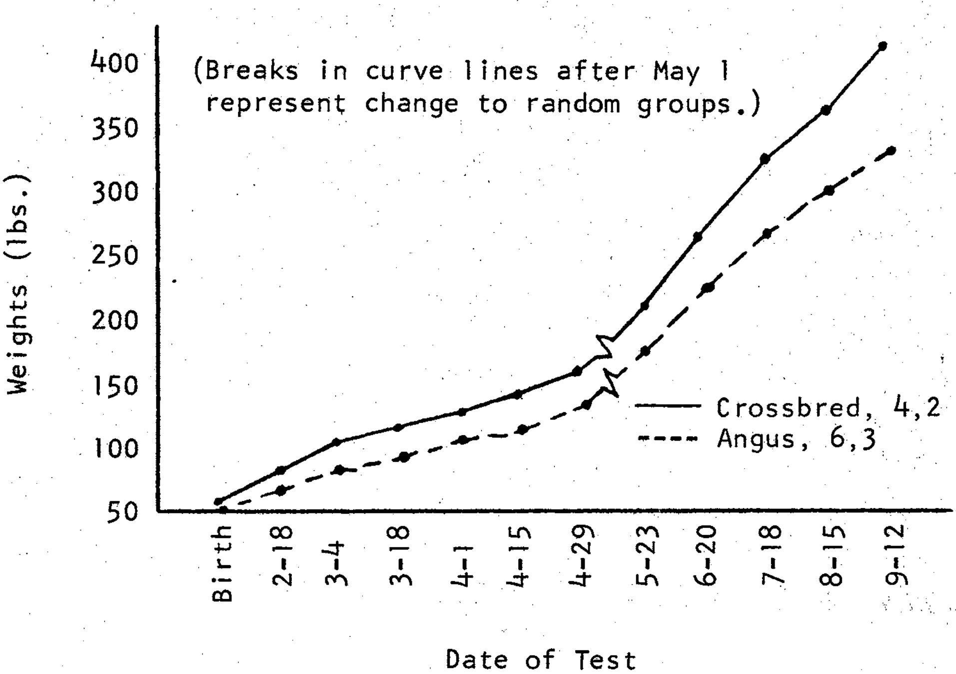

Figure 8. Mean Calf Weights for Group 1 From Birth to Weaning

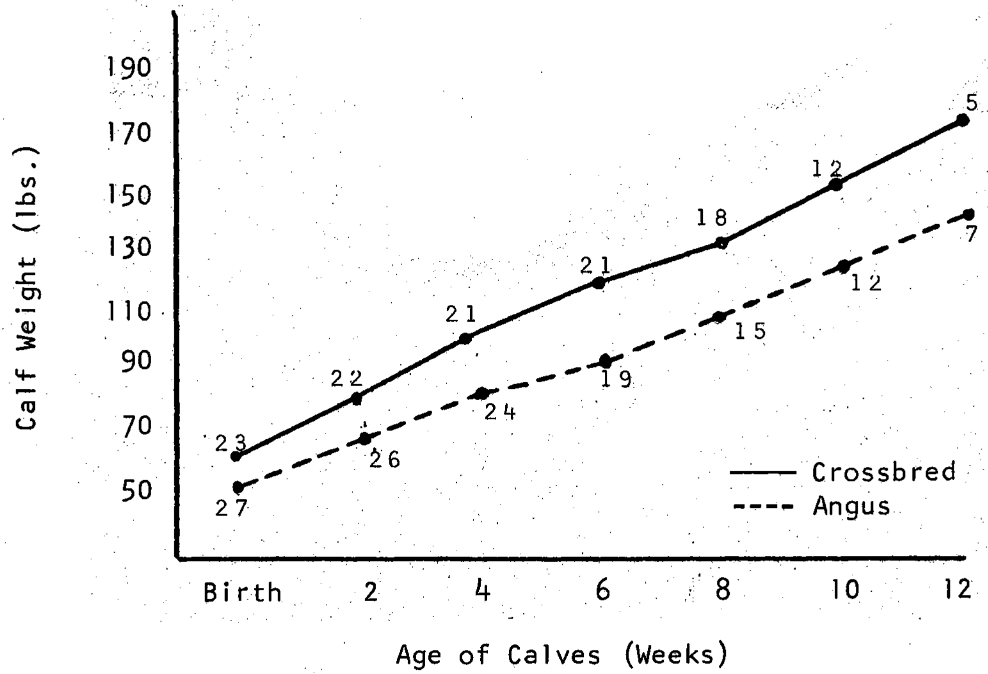

Figure 10. Means of Calf Weights Pooled Within Breed at 2 Week Intervals During Early Lactation

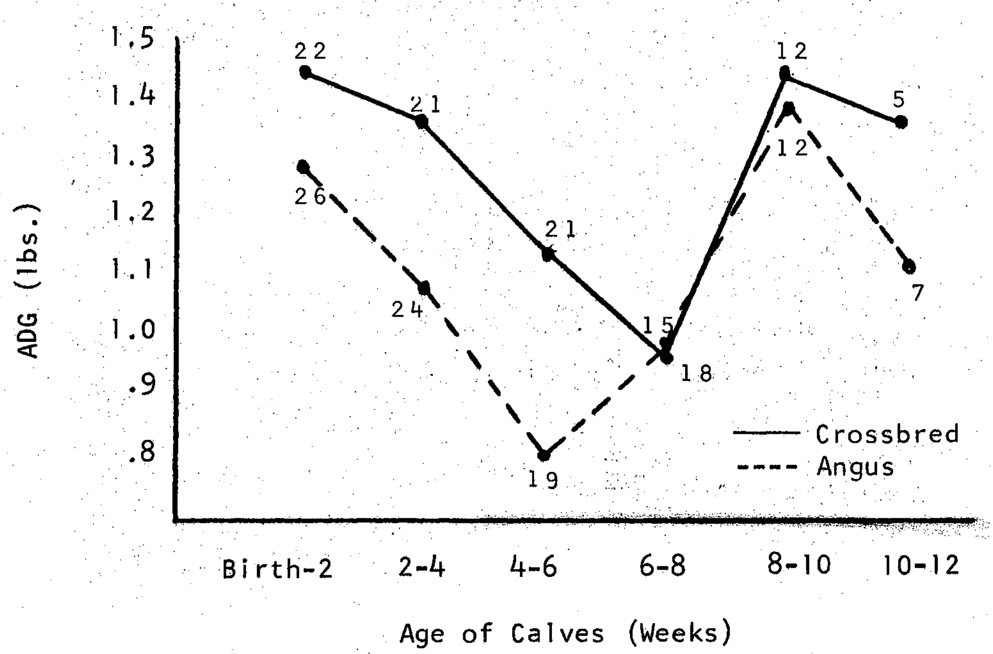

Figure 11. ADG of Calves Between 2 Week Intervals Pooled Within Breed During Early Lactation

in both breeds was within a range of 1.3 to 1.4 from birth to 2 weeks; it decreased during the 4-8 week period, then increased rapidly during 8-10 weeks. These curves also reflect the effects of milk yield and grazing conditions.

TABLE XI

MEANS AND STANDARD ERRORS OF CALF WEIGHTS POOLED WITHIN BREED AT TWO WEEK INTERVALS DURING EARLY LACTATION[1]

	Crossbred		Angus		
Weeks	No.	Mean ± SE	No.	Mean ± SE	Diff.
2	22	87.0 ± 2.04	26	69.8 ± 2.00	17.2**
4	21	106.1 ± 2.62	24	85.0 ± 2,30	21.1**
6	21	122.2 ± 2.68	19	96.3 ± 2.29	25.9**
8	18	135.7 ± 3.27	15	110.2 ± 1.65	25.5**
10	12	155.8 ± 5.48	12	129.6 ± 4.07	26.2**
12	5	174.8 ± 7.50	7	145.4 ± 3.50	29.4**

[1]Weight in lbs.

**($P < .01$)

Summer and Total Calf Growth

The pooled within breed calf weights for each monthly test period are given in Table XII. The difference in weights between the back-cross and Angus calves continued to increase from 50.6 pounds in May to

TABLE XII

POOLED MEANS AND STANDARD ERRORS OF SUMMER CALF WEIGHTS

Breed	No.	Month of Test - Weight in Lbs.									
		May		June		July		Aug.		Sept.	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Crossbred	13	194.2	± 10.90	253.1	± 12.85	310.7	± 16.43	350.7	± 17.86	393.6	± 19.24
Angus	13	143.6	± 10.45	189.5	± 13.78	239.1	± 13.99	273.6	± 14.51	310.3	± 17.23
Diff.		50.6*		63.6*		71.6*		77.1*		83.3*	

*($P < .01$)

83.3 pounds in September. The rate of gain was the highest from May to July with the range being 2.0-2.5 for the crossbreds and 1.8-2.0 pounds per day for the Angus which was probably due to the larger calves grazing more of the highly palatable grass available during this period and not being so dependent on milk.

Table XIII presents the adjusted 205 day weaning weights and grades within sex. The differences in weights between the breeds of 44.5 pounds for the steers and 76 pounds for the heifers were statistically significant. The cause of the larger difference for the heifers is not apparent from these data. The crossbred cows not only produced significantly more milk, but their heavier calves were able to consume that milk and gain considerably more weight by weaning. Since other studies of this exact type are not available, these results will be compared to studies of a similar type. This weight advantage of the crossbreds was greater than the 27 pound difference reported by Koch et al. (1968) between straightbred and crosses of British beef breeds, and comparable to the 72 pound difference reported by Pahnish et al. (1969) between Brown Swiss and beef crossbred cows. The crossbreds in the present study averaged lower than the 460 pounds of the Angus-Holstein crossbreds under drylot reported by Wilson et al. (1969) probably because of the lower feed level. This increase of 15 percent in weaning weight approaches the advantage for crossbreds stated by Cundiff (1970).

The conformation grades and condition scores were quite similar, all being near low choice. This would indicate that the dairy blood did not appreciably lower the quality or beefy appearance of the backcross calves. Pahnish et al. (1969) stated that the Brown Swiss crossbred calves graded 1.5 to 2.3 units lower than the beef crossbreds.

TABLE XIII

ADJUSTED 205 DAY WEANING WEIGHTS AND GRADES OF CALVES

Breed	Sex	No.	205 Day Weights Ave. Lbs. ± SE	Conformation Grade	Condition Score
Crossbred	Steers	11	430.5 ± 9.59	11.54	12.05
	Heifers	12	419.5 ± 9.18		
Angus	Steers	10	386.0 ± 15.0	11.76	11.97
	Heifers	17	343.5 ± 11.5		
Diff.	Steers		44.5*	-.26	.08
	Heifers		76.0**		

*(P < .05)
**(P < .01)

The effects of calving date on 205 day adjusted total calf gain is shown in Figure 12. A comparison of the mean total calf gain among the week groups (different calving dates) can be made. Means were adjusted for sex by using the standard method of increasing the heifer's gain by five percent. The only significant difference was in group 1 between breeds and much variation existed in later groups. There was a very slight trend for earlier calves to have a higher adjusted gain to weaning.

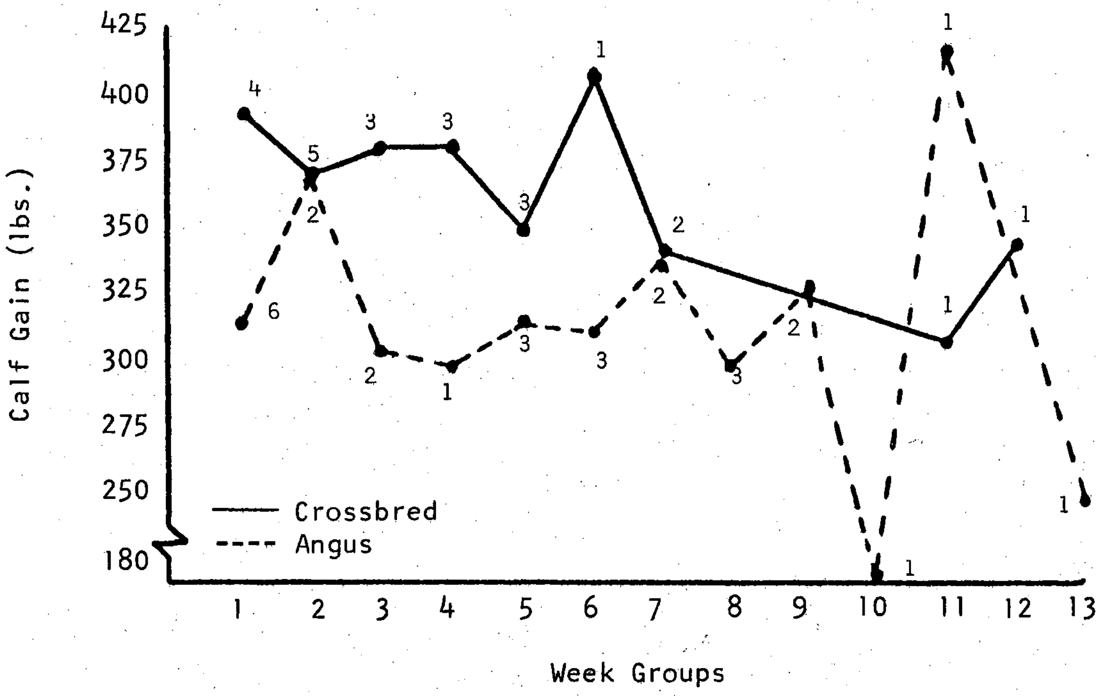

Figure 12. Average Adjusted 205 Day Gain for Each Week Group Adjusted for Sex

Rebreeding

The rebreeding of all cows nursing calves was quite disappointing. Only 22% of the crossbreds and 48% of the Angus cows were observed in heat during the breeding season; however, due to the difficulty of checking all cows for heat in ten pastures these percentages are low. The results of the pregnancy check which were confirmed by the 1970 calving data are presented in Table XIV.

TABLE XIV

SUMMARY OF REBREEDING AND CALVING INTERVAL

Breed	No. Cows Nursing Calves	Cows Rebred		Calving Interval (Days)
		No.	%	
Crossbreds	23	3	13	401
Angus	27	17	63	389
Diff		14	50*	12

*(P< .01)

The conception rate for all cows nursing calves was quite low. Only 3 out of 23 or 13% of the crossbred cows rebred during the 90 day breeding season as compared to 63% of the Angus cows. This large difference of 50% was highly significant (P< .01). The calving interval was slightly longer for the three crossbreds. All heifers that had been open or that had lost calves became pregnant. This would indicate that the feed level was probably too low to support lactation, body growth and rebreeding. This theory is supported by work of Wiltbank et al. (1962 and 1964), Smithson et al. (1964), Turman et al. (1964 and 1965), and Dunn et al. (1969) in which they showed that level of nutrition has a great influence on breeding efficiency. These conception rates were unusually low even for the Angus cows, and may have been caused by the poor nutrient value of the grass. Abundant rainfall was received during the first half of the breeding season which may have caused the grass to have a very high moisture content and to be less nutritious. These results indicate that more available energy was needed by all heifers for rebreeding, with the crossbreds most severely affected because of their higher milk production.

Cow Weight Change

The pattern of cow weight changes from before calving to after weaning is presented in this section. The crossbreds weighed 869 pounds before calving compared to 759 pounds for the Angus giving a significant difference ($P < .01$) in weight of over 110 pounds. However, the condition score of the crossbreds was significantly lower ($P < .01$) than the Angus by 1.04 units (3.26 to 4.30). The cow weight changes between the milk test periods in early lactation varied widely within breed for each week group. Table XV gives the weight changes pooled within breed between two week intervals for early lactation. The crossbreds lost more between all weeks with the differences varying from 2 to 23 pounds. Both breeds lost about 120 pounds during the first 2 weeks after calving which included calving loss, but the crossbreds continued

TABLE XV

MEANS AND STANDARD ERRORS OF COW WEIGHT CHANGES BETWEEN TWO WEEK INTERVALS POOLED WITHIN BREED DURING EARLY LACTATION[1]

Week Intervals	Crossbred No.	Crossbred Mean	Crossbred SE	Angus No.	Angus Mean	Angus SE	Diff.
0-2	22	-122.6 ±	5.68	26	-120.6 ±	3.97	2.0
2-4	21	-17.1 ±	5.22	24	-2.2 ±	3.82	14.9**
4-6	21	-8.5 ±	3.00	19	-5.3 ±	2.83	3.2
6-8	18	-31.7 ±	5.61	14	-14.6 ±	5.7	17.1*
8-10	12	-4.6 ±	7.93	10	+9 ±	10.63	13.6
10-12	4	-32.5 ±	11.99	6	-9.2 ±	6.39	23.3

[1]Weight in lbs.
*(P < .05)
**(P < .01)

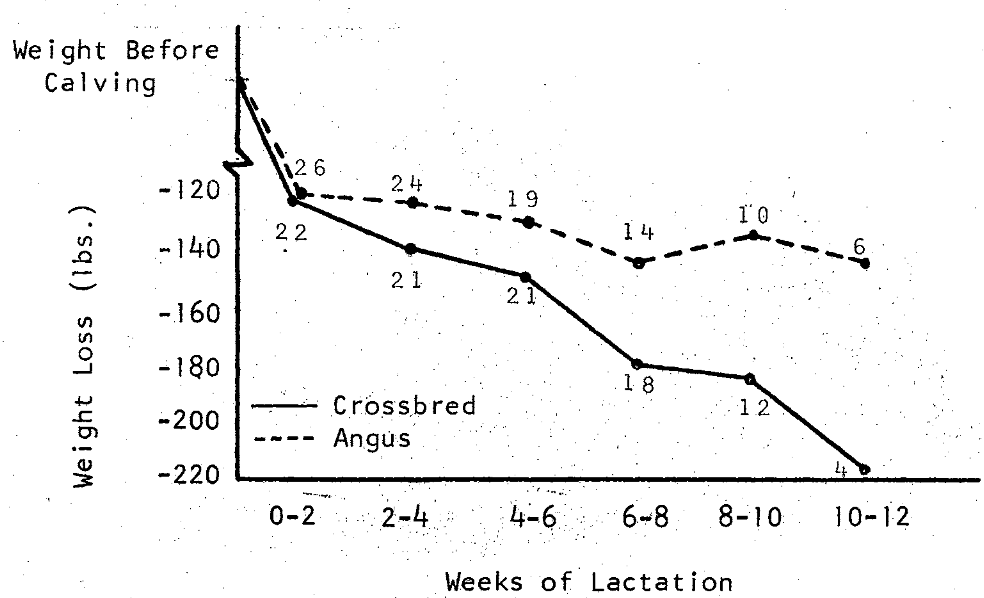

Figure 13. Means of Cow Weight Changes Between 2 Week Intervals Pooled Within Breed

to lose more rapidly than the Angus to the 12th week or about May 1 (Figure 13). The average weights and condition scores pooled within breed corresponding to the above week intervals are presented graphically in Figure 14. The scores for both breeds changed in accordance with the weights.

When pooling the weight loss within breeds, the crossbreds lost an average of 158 pounds from calving to May 1 which was significantly different ($P < .01$) from the loss of 131 pounds for the Angus. This indicates that the crossbreds sacrificed body weight to produce the higher milk yield. The comparison between week groups for weight loss from calving to May 1 gives no trend that early calving cows lost more weight than late calving cows (Figure 15).

The pooled within breed cow weight changes from before calving to each test period during the summer for the randomly selected groups are given in Table XVI. Both breeds showed rapid weight gains during May and continued to gain but the Angus cows gained at a faster rate. Figure 16 shows this weight gain graphically in relationship to the weight before calving starting from May 1 to the middle of September.

The total change in weight and condition score from before calving to after weaning for the cows that nursed calves can be determined from Table XVII. The crossbreds lost a total of 56 pounds compared to only 7 pounds for the Angus cows. This indicates that the Angus were able to gain back almost their entire weight loss by weaning time while the crossbreds did not. The differences in condition scores were a loss of 0.83 for the crossbreds and a loss of 0.26 for the Angus. It appears from these data that the crossbreds needed a higher energy level than these range conditions provided to produce the larger quantity of milk

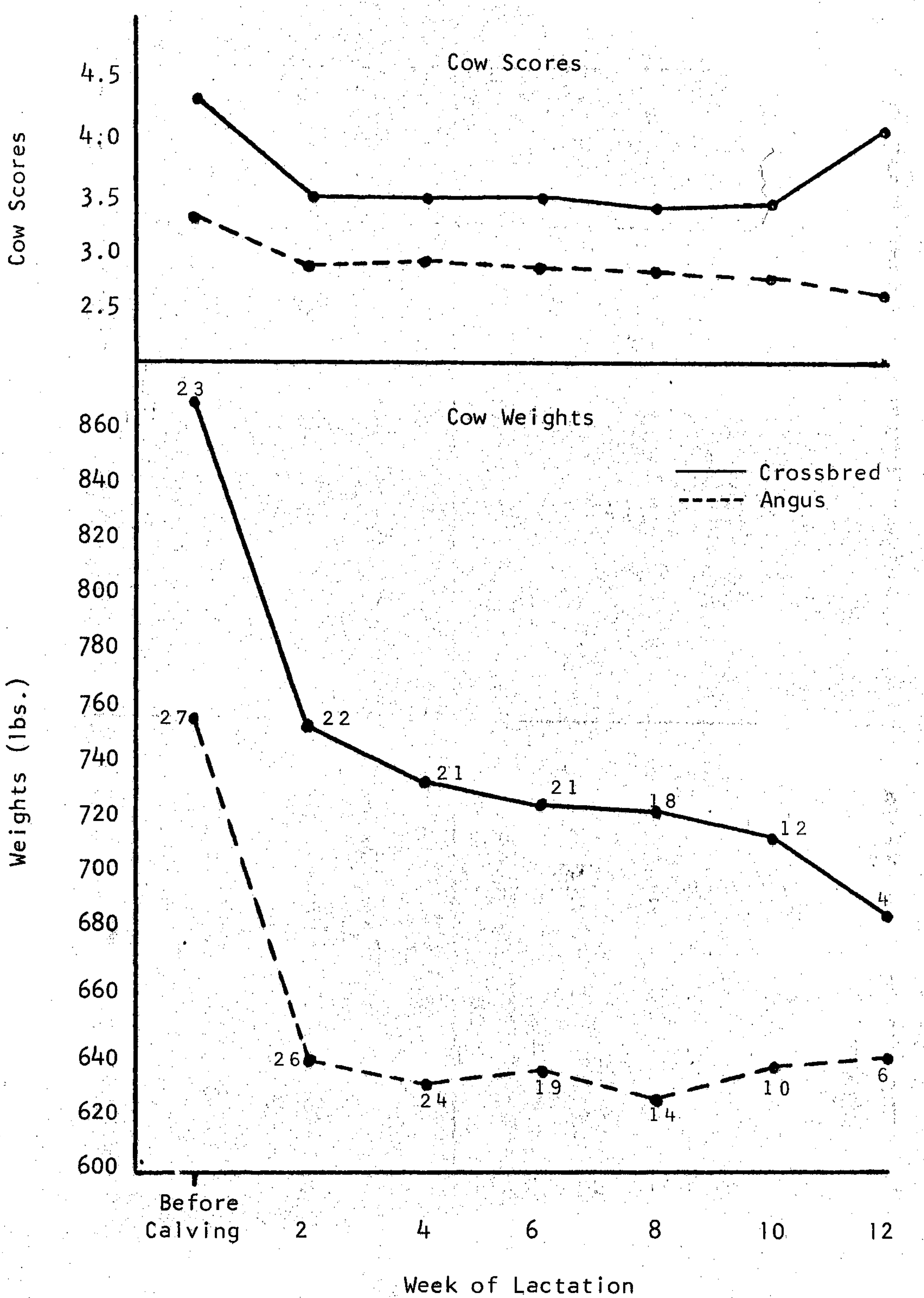

Figure 14. Means of Cow Weights and Scores at 2 Week Intervals Pooled Within Breed

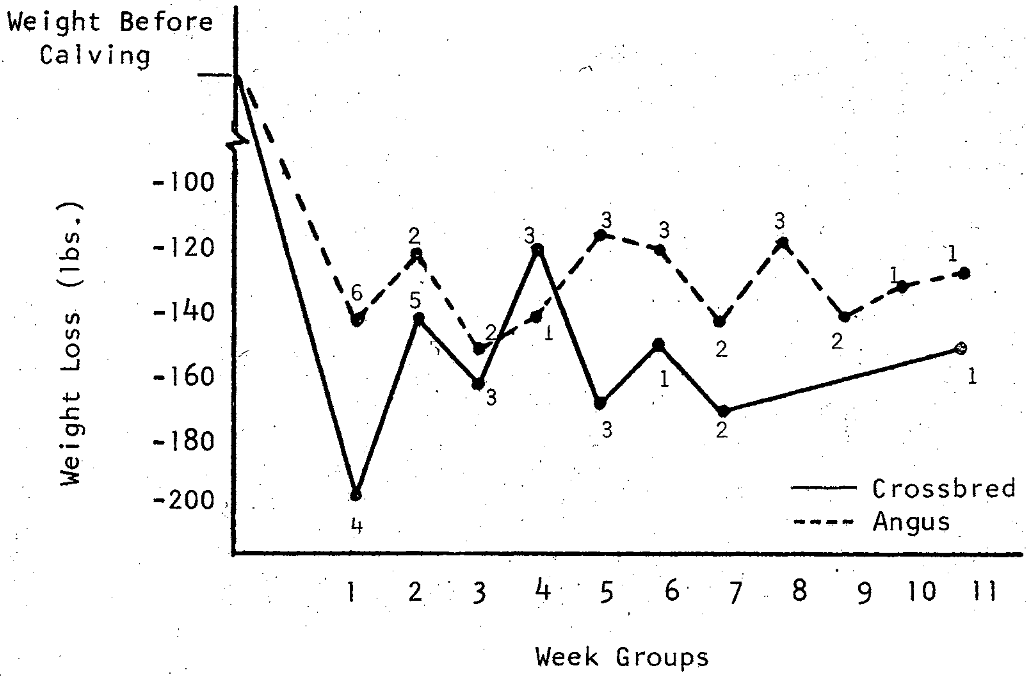

Figure 15. Average Cow Weight Loss From Before Calving to May 1 for Week Groups

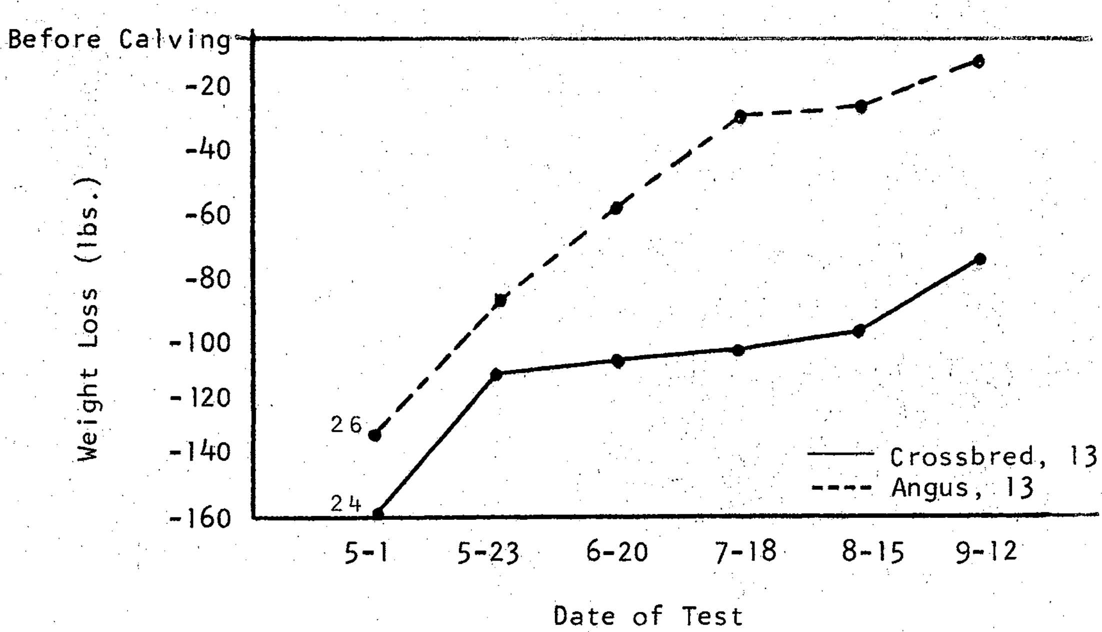

Figure 16. Means of Cow Weight Changes From Before Calving During Summer

TABLE XVI

POOLED MEANS AND STANDARD ERRORS FOR COW WEIGHT CHANGES FROM BEFORE CALVING DURING SUMMER

		Month of Test - Weight in Lbs.									
		May		June		July		Aug.		Sept.	
Breed	No.	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Crossbred	13	-112	± 12.24	-106.7	± 12.6	-104.0	± 15.04	-97.6	± 10.97	-75.2	± 9.26
Angus	13	-68.9	± 5.25	-57.2	± 4.79	-27.9	± 9.12	-24.2	± 15.2	-10.2	± 15.26

and heavier calf and still maintain their body weight. This agrees with the results of Wilson et al. (1969) that lactating Angus-Holstein cows could not maintain their body weight on the recommended energy level for lactating beef cows.

TABLE XVII

MEANS AND STANDARD ERRORS OF COW WEIGHTS AND CONDITION SCORES BEFORE CALVING AND AFTER WEANING

	Before Calving		After Weaning	
Breed	Weights (lbs) SE	Scores SE	Weights (lbs) SE	Scores SE
Crossbreds	869 ± 14.6	3.26 ± .07	813 ± 6.25	2.43 ± .14
Angus	759 ± 12.1	4.30 ± .13	752 ± 15.86	4.04 ± .15

Correlations and Regressions

The association of milk production with calf gain and other traits will be discussed since there had been much interest in this area. However, it must be emphasized that these data do not fit the criteria for a good correlation study because the sample numbers were quite small and calving date was not normally distributed.

Table XVIII gives the linear and partial correlations (holding calving date constant) within breed for several traits. When interpreting these results it should be remembered that they cannot be relied upon too heavily due to the confounding of the data. Birth weight was

TABLE XVIII

LINEAR AND PARTIAL CORRELATION COEFFICIENTS WITHIN BREED

Traits and Breeds	No.	Birth Wt. Lin.	Birth Wt. Part.	Total Calf Gain to May 1 Lin.	Total Calf Gain to May 1 Part.	Cow Weight Loss to May 1 Lin.	Cow Weight Loss to May 1 Part.	Calving Interval[1] Lin.	Calving Interval[1] Part.
Total Milk to May 1									
Crossbred	22	.07	.52*	.78**	.14	.30	.37	--	--
Angus	26	-.09	-.44	.90**	.60**	.32	.16	.43	.38
Total Milk to Weaning[2]				Total Calf Gain to Weaning					
Crossbred	13			.11	.21				
Angus	13			.78**	.68**				

[1] Correlations on only 17 Angus and no crossbreds (due to only 3 crossbreds rebreeding).

[2] Correlated only to total calf gain because involved only selected groups.

*Rho significant from 0 ($P < .05$)

**($P < .01$)

significantly correlated ($P < .05$) with total milk to May in the crossbreds which agrees with Drewry et al. (1959), Schwulst et al. (1966), Melton et al. (1967), and Dickey et al. (1970). The high partial correlations of total milk to May 1 versus total gain to May 1 and total milk to weaning versus total gain to weaning in the Angus and not in the crossbreds may indicate that the milk supply is not the limiting factor for growth in the crossbreds but is in the Angus. However, it was observed that the crossbred cows allowed other calves to nurse them which was probably a factor in this low correlation. This correlation of 0.60 for the Angus for early lactation is lower than reports of Gifford (1949) and Gleddie and Berg (1968). The 0.68 correlation for the entire lactation lies in the upper part of the range of values reported by numerous workers.

A low non-significant positive correlation was found between total milk to May 1 and cow weight loss to May 1 meaning that the cows may have had the tendency to sacrifice body weight for milk production. A small positive correlation was observed between milk yield to May 1 and calving interval.

To get an estimate of the pounds of milk required to produce a pound of calf gain during the entire lactation period, the average milk production of each breed was divided by the average total calf gain. The estimate for the crossbreds was 7.1 pounds compared to 6.0 pounds for the Angus which indicates that the Angus may be slightly more efficient.

Regression coefficients were calculated to obtain an estimate of the increase in calf gain per pound increase in milk production. However, it should be pointed out that these data were poor for regression analysis because of the limited number of animals involved and the large variation in the traits, so values are only rough estimates. The coefficients of calf gain to May 1 on total milk consumed to May 1 were low for both the crossbreds (0.079) and the Angus (0.1146). The coefficients for total calf gain to weaning on total milk consumed to weaning were even lower. The values were 0.016 for the crossbreds and 0.092 for the Angus. The extremely low coefficient for the crossbreds of 0.016 was probably due to the following situation. It was observed that on the range some of the crossbred cows would allow calves other than their own to nurse. If the calf from a low producing cow was able to obtain milk from a high producing cow, this would cause the actual milk consumption and the calf gain to equalize which would cause the regression coefficient to be low.

CHAPTER V

SUMMARY

The productivity of 40 two-year-old Angus-Holstein crossbreds was compared to 42 grade Angus heifers under tall grass range conditions from breeding as yearlings to weaning of the first calf. The characteristics evaluated were calving percent, milk production, calf weights, rebreeding performance, and cow weight and condition score changes. The heifers were pasture-bred at the Lake Carl Blackwell range by yearling Angus bulls to calve during the spring. The heifers were on native grass at all times and were supplemented with prairie hay and protein cubes in the winter. Milk production was estimated by the calf nursing method at two week intervals to May 1 and thereafter at four week intervals until weaning. Calf weights and cow weights and condition scores were taken at each milk test. All calves were weaned at an average age of 205 days. Cows were pregnancy checked to determine rebreeding performance.

The crossbred heifers had a five percent higher conception rate and had eight percent more live calves than the Angus heifers. The average calving date was ten days earlier for the crossbreds and their calves weighed 15 pounds more at birth. The crossbred cows produced more milk at all test periods. During the first 60 day adjusted lactation period the crossbreds produced 253 pounds (4.21 pounds/day) more than the Angus. The average adjusted 200 day total milk production was 2502 pounds (12.5

pounds/day) for the crossbreds compared to 1750 pounds (8.76 pounds/day) for the Angus. The overall milk production curves paralleled the feed conditions, especially for the crossbreds, with a low in March and a peak in May and then a decline to weaning. These data suggest that time of calving in relation to the grazing season has a large effect on milk production.

The 15 pound birth weight margin in favor of the crossbred calves increased to 29 pounds at 12 weeks and 60 pounds at weaning. The average daily gain during early lactation followed the milk production curves and feed conditions. The average 205 day adjusted weaning weight of the crossbred steer calves was 44 pounds heavier than the Angus steer calves, while the crossbred heifer calves weighed 76 pounds heavier than the Angus heifer calves. The grades and scores were similar in both breeds.

Only 13 percent of the crossbred cows that nursed calves rebred compared to 63 percent of the Angus cows. These data indicate that a higher energy level than these range conditions provided was needed by all heifers for rebreeding, with the crossbreds most severely affected because of their higher milk production. The loss in cow weight for the crossbreds was 158 pounds from before calving to May 1 compared to 131 pound loss for the Angus. The total loss during the entire lactation period was only 7 pounds for the Angus compared to 56 pounds for the crossbreds indicating the faster gain during the summer for the Angus. The correlation of total milk to total calf gain was 0.68 in the Angus but 0.21 in the crossbreds. The Angus required 6.0 pounds of milk/ pound of gain during the entire lactation compared to 7.1 pounds for crossbreds.

In conclusion, these data suggest that the crossbreds are capable of producing more milk and heavier weaning calves but need a higher level of nutrition to rebreed and maintain their body weight.

LITERATURE CITED

Anthony, Brady W., Paul Parks, E. L. Mayton, L. V. Brown, J. G. Starling and T. B. Patterson. 1959. New technique for securing milk production data for beef cows nursing calves in nutrition studies. J. Anim. Sci. 18:1541. (Abstr.)

Bond, James and J. N. Wiltbank. 1970. Effects of energy and protein on estrus, conception rate, growth and milk production of beef females. J. Anim. Sci. 30:438.

Boyd, Louis J., D. M. Seath and Durward Olds. 1954. Relationship between level of milk production and breeding efficiency in dairy cattle. J. Anim. Sci. 13:89.

Boyd, L. J. 1967. Does production affect breeding efficiency. Hoards Dairyman 112:1276.

Brinks, J. S., R. T. Clark, N. M. Kieffer and J. R. Queenberry. 1962. Mature weight in Hereford range cow--heritability, repeatability, and relationship to calf performance. J. Anim. Sci. 21:501.

Brumby, P. T., D. K. Walker and R. M. Gallagher. 1963. Factors associated with growth in beef cattle. New Zealand J. Agr. Res. 6:526.

Carman, G. M. 1955. Interrelations of milk production and breeding efficiency in dairy cows. J. Anim. Sci. 14:753.

Christian, L. L., E. R. Hauser and A. B. Chapman. 1965. Association of preweaning and postweaning traits with weaning weight in cattle. J. Anim. Sci. 24:652.

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

Cole, Leon J. and Ivar Johansson. 1948. Inheritance in crosses of Jersey and Holstein-Friesian with Aberdeen-Angus cattle. Amer. Natur. 82:265.

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

Dawson, W. M., A. C. Cook and B. Knapp. 1960. Milk production of beef Shorthorn cows. J. Anim. Sci. 19:502.

Dickey, James R., M. Koger, D. E. Franke and W. C. Burns. 1970. Milk production in beef cattle. J. Anim. Sci. 30:317. (Abstr.)

Drewry, 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.

Dunn, T. G., J. E. Ingalls, D. R. Zimmerman and J. N. Wiltbank. 1969. Reproductive performance of 2-year-old Hereford and Angus heifers as influenced by pre- and post-calving energy intake. J. Anim. Sci. 29:719.

England, Noah, James Brinks, Ralph Bogart, David C. England and R. T. Clark. 1961. Factors affecting calf weight gains during the suckling period. J. Anim. Sci. 20:672.

Furr, R. D. and A. B. Nelson. 1964. 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.

Gaines, W. L. 1927. Milk yield in relation to recurrence of conception. J. Dairy Sci. 10:117.

Gaines, W. L. and J. R. Palfrey. 1931. Length of calving interval and average milk yield. J. Dairy Sci. 14:294.

Gifford, Warren. 1949. Importance of high milk production in beef cows found overestimated. J. Anim. Sci. 8:605. (Abstr.)

Gifford, Warren. 1953. Milk production, milk production of dams and growth of calves. Ark. Agr. Exp. Stat. Bul. 531.

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

Gowen, J. W. 1918. Studies in inheritance of certain characters of crosses between dairy and beef breeds of cattle. J. Agr. Res. 15:1.

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

Howes, J. R., J. F. Hentges, A. C. Warnick and T. J. Cunha. 1958. Yield and composition of milk from Brahman and Hereford heifers fed two levels of protein and the correlated calf growth. J. Anim. Sci. 17:1222. (Abstr.)

Klett, R. H., T. R. Mason and J. K. Riggs. 1965. Milk production of beef cows and its relationship to the weaning weight of their calves. J. Anim. Sci. 24:586.

Knapp, Bradford, Jr., A. L. Baker, J. R. Queensberry and R. T. Clark. 1942. Growth and production factors in range cattle. Mont. Agri. Exp. Sta. Bul. 400.

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

Kress, D. P., E. R. Hauser and A. B. Chapman. 1968. Factors affecting weaning weight in beef cattle. J. Anim. Sci. 27:1128. (Abstr.)

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

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

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.

Montsma, G. 1960. Observations of milk yield, calf growth and conversion rate on three types of cattle in Ghana. Biol. Abstr. 36:7820.

Nelms, G. E. and Ralph Bogart. 1956. The effects of birth weight, age of dam and time of birth on suckling gains of beef calves. J. Anim. Sci. 15:662.

Neville, W. E., Jr., D. M. Baird and O. E. Sell. 1960. Influence of sire, dam's milk production, three levels of nutrition and other factors on 120 and 240 day weight of Hereford calves. J. Anim. Sci. 19:1223.

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.

Olds, Durward and D. M. Seath. 1953. Repeatability, heritability and the effect of level of milk production on the occurrence of first estrus after calving in dairy cattle. J. Anim. Sci. 12:10.

Pahnish, O. F., J. S. Brinks, J. J. Urick, B. W. Knapp and T. M. Riley. 1969. Results from crossing beef x beef and beef x dairy breeds: Calf performance to weaning. J. Anim. Sci. 28:291.

Pearson, Lucia, R. K. Waugh, B. Salazar, F. M. Botero and O. Acosta. 1968. Milking performance of Blanco Orejinegro and Jersey crossbred cattle. J. Agr. Sci. 70:65.

Rollins, W. C. and H. R. Guilbert. 1954. Factors affecting the growth of beef calves during the suckling period. J. Anim. Sci. 13:517.

Rook, J. A. F. and R. C. Campling. 1965. Effects of stage and numbers of lactation on the yield and composition of cow's milk. J. Dairy Res. 32:45.

Schilling, Prentiss E. and Noah C. England. 1968. Some factors affecting reproduction in beef cattle. J. Anim. Sci. 27:1363.

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

Serwanja, J. C., J. A. Welch and H. E. Kidder. 1969. Dams milk yield and composition on growth of Angus calves. J. Anim. Sci. 29:198. (Abstr.)

Smithson, L., S. A. Ewing, R. E. Renbarger and L. S. Pope. 1964. Effects of high or low winter feed levels in alternate years on growth and development of beef heifers. Okla. Agr. Exp. Sta. MP 74:78.

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

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

Turman, E. J., L. Smithson, L. S. Pope, R. E. Renbarger and D. F. Stephens. 1964. Effects of feed level before and after calving on the performance of two-year-old heifers. Okla. Agr. Exp. Sta. MP 74:10.

Turman, E. J., L. S. Pope and D. F. Stephens. 1965. Some factors associated with the rebreeding of two-year-old Hereford heifers on high, moderate, and low levels of winter feeding. Okla. Agr. Exp. Sta. MP 76:25.

Turner, J. W., B. R. Farthing and G. L. Robertson. 1968. Heterosis in reproduction performance of beef cows. J. Anim. Sci. 27:336.

Vaccaro, Rodolfo and E. U. Dillard. 1966. Relationship of dam's weight and weight changes to calf's growth rate in Hereford cattle. J. Anim. Sci. 25:1063.

Wilson, G. F. 1964. The influence of date of calving on milk production. New Zealand J. Agr. Res. 7:80.

Wilson, L. L., J. E. Gillooly, M. C. Rugh, C. E. Thompson and H. R. Purdy. 1969. Effects 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.

Wiltbank, J. N., W. W. Rowden, J. E. Ingalls, K. E. Gregory and R. M. Koch. 1962. Effect of energy level on reproductive phenomena of mature Hereford cows. J. Anim. Sci. 21:219.

Wiltbank, J. N., W. W. Rowden, J. E. Ingalls and D. R. Zimmerman. 1964. Influence of post-partum energy level on reproductive performance of Hereford cows restricted in energy intake prior to calving. J. Anim. Sci. 23:1049.

Wiltbank, J. N., K. E. Gregory, J. A. Rothlisberger, J. E. Ingalls and C. W. Kasson. 1967. Fertility in beef cows bred to produce straightbred and crossbred calves. J. Anim. Sci. 26:1005.

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

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