THE RELATIONSHIP OF MILK PRODUCTION OF BEEF COWS AND THE GAINS OF THEIR SUCKLING CALVES

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INTRODUCTION

The beef cow is the foundation of the beef industry and represents the base for different systems of beef production. In many respects, she differs from females of other species and is a relatively inefficient producer, in terms of milk yield. Successful cattlemen have long recognized the importance of high milk production in the beef cow, as it influences the weaning weight and quality of her calf. However, many producers, especially purebred breeders, have not given enough attention to this factor. Also, due to the nature of the usual beef operation, a measure of milk production in the female is difficult to obtain.

The milk supplied to the calf is of considerable importance since it furnishes most of the calf's nutritive requirements for the first 3 to 4 months of the growing period and influences the economy of its gain. Increasing the milk producing ability of the beef cow can only be accomplished through improved breeding and feeding practices.

Several studies have been carried out in relation to the amount of milk produced by the beef cow and its effect on the calf growth. Most authors agree in their results, but further information is needed in respect to certain relationships of milk production of the dam and the weight gain of the calf, particularly where the dam has been subjected to different winter feeding regimes.

Therefore, a study was undertaken at the Fort Reno Experiment Station in the summer of 1961 to determine some of the relationships between milk

yields of three different age groups of cows and calf gains by periods, within the different winter treatments imposed on the cows. The correlation of repeated samplings of milk production of the same cow was determined to show the repeatability of high or low production.

REVIEW OF LITERATURE

A convenient and reliable method for measuring milk production in the beef cow has hampered research workers in this field. Several different techniques have been adapted to beef cattle to obtain milk production, the most desirable being that one which will provide the most accurate record without disturbing the cow's natural environment.

The significance of milk production as associated with calf gains needs further study. Also further knowledge of the variation of milk production within a lactation, irrespective of treatment, is desirable in view of the differences encountered in obtaining such information.

Methods of Measuring Milk Production of Beef Cows

Several techniques used to estimate the milk production of ewes have not been used extensively with beef cattle. Barnicoat (1949), investigating the various methods of estimating milk production in the ewe, found that hand-milking, machine milking and pituitrin injections were not as satisfactory as estimating the yields from the milk intake of their lambs. However, McCance (1959) devised a hormonal method which provided simpler means than suckling of lambs. The yields were measured by hand-milking following injection of posterior pituitary extract (PPE) to obtain milk ejection. McCance (1959) claimed to obtain higher yields by this method.

In cows, these methods have also been used but to a lesser extent. While weighing the calves before and after nursing has been the most

widley used technique by most workers, several modifications have been introduced.

Gifford (1953), estimating production each month, separated calves for three days each month and allowed them to suckle their dams twice daily. On the second day, one half of the udder of each cow was milked by hand while the calf suckled the other half. The following day the opposite half was milked by hand. The two records were combined and used as an estimate of one day's production. Since calves received approximately one half the quantity of milk that they usually suckled, the effects of any limitations on capacity of consumption were eliminated to a great extent. A very similar technique was applied by Howes (1958).

Drewry et al. (1959) and Dawson et al. (1960) used the hand-milking technique but differed in the frequency of the samplings. While the former measured milk production in the first, third, and sixth month of lactation, the later obtained estimates at weekly intervals.

Lampkin and Lampkin (1960) separated calves from their dams for the overnight period of fourteen hours and regarded the milk obtained as 54 percent of the total daily yield. At twelve weeks the standard deviation of the errors amounted roughly to seven gallons per cow which, by milking once a week, permitted them to differentiate between yields of individual cows.

A new technique for securing milk production from beef cows nursing calves was devised by Anthony et al. (1959) by which the cow is separated from the calf and injected 2 c. c. of oxytocin. Then the cow is milked by machine as a pretest; its yield is weighed or sampled. The cow remains separated from her calf overnight and twelve hours after the first milking her yield is estimated again by the same procedure. Production

is reported on a twelve hour FCM basis.

Konkoly and Barczy (1954) studied the yields of 27 Brown Swiss cows which suckled their calves and that of 26 cows milked without suckling. The initial daily production, 30 weeks after calving and total production was in favor of the cows milked without suckling. There were greater fluctuations in the yields of the cows that suckled than in those of cows that did not.

Sere del Campo (1946) outlined the relative importance of the factors affecting variance in milk recordings. In descending order of importance the factors were: individual differences between cows; the method of calculating yield from records; the time elapsing between calving and the frequency with which records are made; the remainder of the variance being due to interaction among these factors. Studying the different frequencies of collection he found that the influence upon accuracy of results was small unless the interval between recordings exceeded 42 days. At 60 days, accuracy decreased considerably.

Influence of Milk Production on Gains of Suckling Calves

Black and Knapp (1936), working with several beef and dairy breeds, found that average daily gain from birth to weaning and from weaning to slaughter are negatively correlated, showing that animals which grow at a greater rate during the suckling stage tend to gain at a slower rate thereafter. Gain from birth to weaning was highly correlated with pounds of milk received during this period. Therefore, efficiency of gains prior to weaning are, to a great extent, a measure of the milk production of the dam. No milk production records, however, were obtained in the study.

Knapp and Black (1941), in an attempt to determine the factors influencing the rate of gain in beef calves during the suckling period, found that milk consumption had the greatest influence, followed in order by the amount of hay and grain being consumed by the calves, although the difference was not statistically significant. Simple correlation between daily gain and quantity of milk produced was 0.517 ($P < 0.01$). The multiple correlation between daily gain and milk, grain, and hay was 0.641 ($P < 0.01$). The combined influence of these three variables accounted for 41 percent of the variation in rate of gain during the suckling period. Partial correlations between daily gain and other items were:

Quantity of milk (grain and hay constant), :0.619 ($P < 0.01$),
quantity of hay (milk and grain constant), :0.308 ($P < 0.05$), and
quantity of grain (milk and hay constant), :0.188 (not significant).

Vincke et al. (1933), Knapp et al. (1942), and Rollins et al. (1954) found that young cows and old cows produce calves that grow slower to four months of age and are lighter in weight at weaning than calves produced by cows of intermediate age. These studies indicate that the "prime of life" of a beef cow under Plains' conditions is between the ages of six and eight years.

Wallace (1948) and Barnicoat et al. (1949) have shown that the live weight of the lamb is highly correlated with milk yield. The correlation coefficients were approximately 0.90 at one month of age, decreasing for each succeeding month, until it was not significant by the fourth month of age. The intake of supplementary food increased as the milk intake decreased, with a declining correlation between milk yield and live weight of lamb. However, Burris and Baugus (1955) obtained a correlation of 0.83 ($P < 0.01$) between total milk consumption and total gain of the lamb

to sixteen weeks of lactation.

Gifford (1949, 1953), in a very extensive study involving 28 Hereford, 7 Aberdeen-Angus, and 5 Shorthorn cows, collected the records of milk production and the growth records of their calves. Milk yield was obtained during a two-day period each month by obtaining the production of one half of the udder one day and the other half the following day. The combined yield was used as an estimate of one day's production. Cows were kept on pasture 9 to 10 months and the remainder of the year receiving silage, prairie hay, and cottonseed cake. Calves were creep fed during the winter months.

The average daily gain in weight each month from birth to weaning ranged from 1.1 to 1.6 pounds, even though the average daily milk production of the dams ranged from 8.5 pounds during the first month to 4.1 pounds during the eighth month. Milk production of Shorthorns and Aberdeen-Angus cows was slightly higher. The average milk production for all cows was 1,498 pounds. The data indicated that the maximum milk production of beef cows normally attained during the first six weeks of lactation may be affected by the capacity of the young calf to consume the milk. If milk is not removed from the udder, the yield from high producing cows tends to level off to 12 to 15 pounds daily before the normal decline occurs. Beef cows between the ages of two and three years produced less milk than cows of any other age studied. The quantity of milk produced had a tendency to increase up to about six years. These results are in general agreement with the finding of Rollins et al. (1954).

The gross correlation between daily milk production of Hereford dams and daily weight gain of their calves was 0.60, 0.71, 0.52, and 0.35 for the first, second, third, and fourth month, respectively. After the

fourth month there was no significant relation between the two items. Gifford (1949, 1953) concluded that the importance of high milk production in beef cows has been overestimated.

The units of monthly gain in body dimensions such as height at withers, depth of chest, width of shoulders, and others were quite constant month by month, although some slight decline occurred with an increase in age.

The effect of low milk production on growth of calves was studied by dividing cows into three groups: Group I - cows producing less than 6.5 pounds of milk during any day in the lactation; group II - cows producing between 6.5 and 12.9 pounds of milk per day; group III - cows producing 13 pounds of milk or over per day. The three groups produced calves with a weaning weight average of 325, 405, and 475, respectively.

Calves from low producing cows gained lower during the first three months, but, thereafter, when milk production declined, they made normal gains. Calves from highest producing dams gained very fast during the first three months, but when milk yield declined, their growth was similar to those from low producers. Therefore, a minimum milk production of six to eight pounds per day during the first three months of lactation is required to produce a 400 pound calf or larger at weaning time, under the conditions of this study. Daily milk production of no more than 18 pounds per day during the first three months, followed by the normal decline in production, produced calves of 475 to 525 pounds at weaning.

The importance of the amount of milk production and the type of winter forage as it affects calf gains, was studied by Neville et al. (1953) by placing 18 cows on a temporary pasture and 15 cows on a crimson clover pasture. Milk production was obtained and average daily gain of

calves calculated. A positive correlation of 0.41 and 0.44 was found between these two items for the respective pastures. At two weeks of lactation the groups on temporary and clover pasture produced 22 and 15 pounds of milk, respectively, declining by the fourteenth week of lactation to 13 and 12 pounds, respectively. The difference was due to the amount, rather than quality, of pasture. The weights of calves at fourteen weeks were 175 versus 152 pounds, respectively.

Howes et al. (1958) conducted a study with 12 Hereford and 12 Brahman registered heifers allotted at random into two treatment groups receiving 100 and 50 percent of the N.R.C. recommended protein allowances. At subsequent 28-day intervals the cows were suckled and hand milked on two successive days to determine milk yield by two alternative methods. Milk yield and calf growth were significantly higher for the Brahman heifers than for the Hereford heifers, while with older Brahmans the difference over the Herefords was less marked. Heifers receiving the 50 percent protein level of the ration were significantly more affected than the cows, causing a reduction on milk yield, calf growth, and dam's weight at weaning.

Correlations between milk production and calf weight gain were 0.67, 0.83 ($P< 0.01$), 0.50, and 0.45 ($P< 0.05$) respectively for each of the first four months of lactation. The Brahmans were significantly superior to Herefords in milk yield and growth of their calves throughout lactation. Daily calf gains over the first 112 days for the Brahman 100 and 50 percent groups were 1.74 and 1.23 pounds, while those for the Herefords were 1.32 and 0.97 pounds, respectively.

Drewry et al. (1959) studied the relationships among several factors associated with mothering ability of beef cattle. Milk production of 48

Aberdeen-Angus cows was estimated for one day in the first, third, and sixth month of lactation through differences in calf weights before and after nursing. When observations of two years were combined, the estimated milk required to make a pound of gain was 12.5, 10.8, and 6.3 in the first, third, and sixth months of lactation, respectively. These values are similar to those obtained from the milk production and calf gains by Gifford (1953). Drewry and associates noted that older cows were heavier milk producers and that they also gave birth to heavier calves. The correlations between estimated daily milk production of the dam and total calf weight gain from birth were -0.15, 0.35, and 0.48 for the first, third and sixth month of lactation, respectively, suggesting that this relationship may be influenced by the age of the calf. When pounds of milk required per pound of gain and preweaning growth were correlated it seemed to indicate that those calves suckling higher producing dams made the least gain from a pound of milk, probably due to the higher maintenance requirements of the heavier calves.

Multiple correlations and standard partial regressions were also computed using total gain of the calf from birth as the dependent variable. Lactation number, mothering score, daily milk production of the dam, birth weight, age, and suckling time of the calf were used as the independent variables, which accounted for 75, 77, and 60 percent of the variability associated with the total gain of the calf up to one, three, and six months of age, respectively. Therefore the relationship among factors affecting mothering ability changes as the calf increases in age.

Neville et al. (1960) reported, over a period of three years, the influence of sire, dam's milk production, three levels of nutrition and other factors on 120- and 240-day weight of 135 Hereford calves. Cows

were on three different planes of nutrition starting in December and continuing until calves were four months old. The average daily milk production of cows up to eight months, and eight-month calf weights, corrected for sire and sex effects were: Low plane - 8.1 and 400 pounds; Medium plane - 9.6 and 448 pounds; and High plane - 10.5 and 461 pounds, respectively. Regression of eight-month calf weight on dam's milk production in 100 pound units was 8.65, 8.12, and 5.60 for the Low, Medium, and High plane calves, corrected for year, sire, and sex effects. All three values were significantly different. Regression of daily calf gain on daily milk production and their corresponding correlations for the four consecutive periods within year, nutritional level, sex, and sire were 0.064, 0.700; 0.055, 0.610; 0.044, 0.630; and 0.048, 0.640, respectively. A within year, level of nutrition, sex, and sire value of 0.798 (highly significant) was obtained when total milk production was correlated with eight-month calf weight.

Lampkin and Lampkin (1960), working with Brahman cattle in East Africa, conducted a study on the effect of suckling cows on calf growth. They found a mean estimated yield, measuring milk production each week, of 2,486 pounds with a peak daily average of 13.1 pounds during the seventh week for 164 cows over a 36-week lactation. Cows and calves were not supplemented, except during the periods of critical drought when some hay was fed.

When the lactation period was divided into three 12-week periods, 40, 35, and 25 percent of the milk was produced in the first, second, and third period, respectively. Eighteen cows were dry at the time of weaning, although the group as a whole was still producing an average of 6.6 pounds per day in the last week. The average total yield was 3,189

pounds, the lowest cow having produced 1,011 pounds and the highest 4,200 pounds.

Seasonal effects were highly important in both growth rate and weaning weights, accounting for 48 percent of the total variation at any time. Over the total suckling period, male calves gained 9.66 pounds per week on the average, compared with 8.17 pounds for the females. The average weaning weight was 408 and 370 pounds for males and females, respectively.

The amount of milk required per pound of gain in calves during the total suckling period, over the three years concerned, was 7.2 pounds for males and 7.9 for females, with an apparent decrease in milk requirements as the suckling period progressed, indicating the gradual decline in the importance of milk to the calf as it becomes more dependent on grass for nutrients. The between-pair correlations between growth of calves and milk consumption was 0.775 in the male calves and 0.637 in the female calves over the total suckling time. The within-pair correlations were also highly significant at 0.672 and 0.556 ($P < 0.01$) for the males and females, respectively.

Dawson and associates (1960) reported data from an early study at Beltsville, Maryland, showing the milk production of 30 beef Shorthorn cows over a four year period. Calves were weighed before and after nursing on one day each week. Production resulted in an overall average of 4,400 pounds per lactation period of 252 days. The highest yield in the lactation was reached on the average at the end of the second month, at which time the highest individual production reached 22.7 pounds per cow daily. Average production for the last month of lactation was 13.6 pounds per day with a range of 6.0 to 24.0 pounds. Both age of cows and

years had marked effects on milk yields.

Gifford (1953) obtained an average production of 1,498 pounds with a range of 312 pounds in 236 days to 2,458 pounds in 244 days, which is considerably less than the production obtained in the study by Dawson and associates (1960).

Cole and Johansson (1933) reported lifetime milk production records of seven purebred Aberdeen-Angus cows milked twice daily. The average production was approximately 3,100 pounds in 180 days, the best milkers producing up to 11,000 pounds. The yield in the first lactation ranged from 1,027 to 6,746 pounds. Maximum average yield at the fourth week for the first, second, and third lactation periods were 376, 543, and 549 pounds, respectively. Correcting for a 252-day lactation period, these cows produced only around 170 pounds less than the Shorthorns in the study of Dawson and associates (1960).

Dawson also reported the results of an early study at Manhattan, Kansas, with 24 highly selected beef Shorthorn cows milked as if they were dairy cows. Forty-two complete lactations (28 of which were 298 days in length) averaged 4,862 pounds of milk. Production was affected by years and age of cows, the same as in Beltsville, Maryland.

Velasco (1962), in three trials on milk production at three levels of supplemental winter feeding with spring calving cows, reported in one trial an average daily milk production, estimated at monthly intervals, of 6.25 and 8.12 pounds for the low and high levels of winter feeding. Daily gain of calves was also in favor of the cows wintered at a high level. Correlations between milk production and average daily gain of calves were 0.96, 0.68, and 0.57 ($P<0.01$) for the first three months of lactation, respectively, thereafter decreasing considerably until the

month prior to weaning when it increased markedly to 0.77 ($P < 0.01$). Velasco cites studies of several workers who have found comparable results during the period prior to weaning. Correlations for the high level wintered cows were 0.70 ($P < 0.01$) and 0.45 ($P < 0.05$) for the first and second month of lactation, thereafter decreasing considerably to a value of -0.37 for the last month of lactation. Correlations between daily milk production and daily calf gains for the entire period from birth to weaning were 0.76 and 0.55 for the low and high level group cows, respectively.

In a further trial, cows which had been fed for five to six years a low level of supplemental feed during the winter were switched to a high level of feeding with the purpose of studying its effect on milk production. Conversely cows previously fed at a high level, were changed to a low level of winter feed. Cows on high level of winter feeding produced more milk in all the estimates made. Correlations from birth to May 26 between milk production and daily calf gain were 0.73 and 0.72 ($P < 0.01$) for the low and high level cows, respectively.

On a similar study, but with fall-calving cows, Furr (1962) found that four-year-old cows, wintered on a low supplement level and losing more weight during this period than the high supplemental level cows, had a greater increase in milk production during the spring, although they produced 5.92 pounds of milk per head daily as compared to 6.40 pounds for the high level cows during the 172 days of lactation. Correlation coefficients were 0.81 and 0.85 for the two groups, respectively. Three-year-old beef cows wintered on a high level of supplement had a significant increase in milk production, although correlations between daily gain and milk yield were not statistically significant.

The level of winter feeding did not affect the average milk yields of two-year-old beef cows both in small traps and on the range. The average milk yields during the entire lactation and the correlations of calf daily gains with milk yield were 6.82, 0.75 and 6.88, 0.91 for the low and high level cows in traps and 5.33, 0.80 and 6.54, 0.80 for the low and high level cows on the range. All correlations were significant ($P < 0.01$).

Summary

The techniques used to estimate milk production in ewes have also been employed with beef cows but to a lesser extent, the most common being that of measuring milk yield by change of body weight of calf. This technique is slower in calves and not as accurate in terms of weight due to the size of the animal and to losses by defecation and urination. In addition, the milk cannot be sampled for analysis. However, its disadvantages are largely offset because calves consume considerably more milk in relation to body size than the smaller types of animals and because suckling the young seems to provide the most natural environment for estimating the cow's milk yield.

The rate and efficiency of gain of calves during the suckling period depends, to a large extent, on the performance of the dam with regard to milk production. Of the feeds consumed by calves during the suckling period, milk consumption has the greatest influence on gains, followed by hay and grain. The relationship among factors affecting mothering ability changes as the calf increases in age. While total milk production estimates vary widely due to breed, lactation number, technique used in obtaining the yield, etc., there is general agreement that the highest production in the lactation period is attained at six to eight weeks.

This maximum production may be affected by the capacity of the young to consume the milk. If milk is not removed from the udder, high producing cows tend to level off their production to 12 to 15 pounds per day, before normal decline occurs.

Milk production has the tendency to increase in the beef cow up to six years of age, with two- and three-year-old cows producing the least amount. Young and old cows produce calves that grow slower to four months of age and are lighter in weight at weaning than calves from cows of intermediate ages.

Correlations between milk production and average daily gain of calves are significant up to the third or fourth month of age; as lactation progresses milk requirements decrease, indicating a decline in importance of milk to the calf as it becomes more dependent on grass or other feeds for nutrients.

The milk required daily per pound of gain during the suckling period to produce a 400 pound calf at weaning is (approximately) six to eight pounds. Calves from low producing cows make slow gains during the first three months of age, but when milk declines they make normal gains. Those from high producing cows make high gains the first three months, but as milk production declines, they also tend to make normal gains.

MATERIALS AND METHODS

In the fall of 1954, a series of trials were initiated at the Fort Reno Experiment Station to study the effects of different planes of winter nutrition on the growth and reproductive performance of beef heifers. Each fall thereafter, an additional trial was initiated. Data for this study were collected from the fourth, fifth, and sixth repetitions initiated in the fall of 1957, 1958, and 1959, respectively.

Seven month old heifers in Trial IV and V were wintered for three consecutive years on Low, Medium, High, and Very High planes of nutrition from approximately November 1 to mid-April. In 1960, heifers on the Very High level from Trial IV were reverted to a Medium level of winter feeding, while those on Trial V remained on the Very High Level.

Trial VI included a study of alternate levels of winter feeding; i.e. Low the first winter and High the second, etc. Heifers were wintered at Low-Low, Medium throughout, and High-High levels the first and second winters, respectively, which is essentially a repetition of the same three levels used in Trials IV and V. In addition, Low-High and High-Low groups were included, wintered correspondingly at those levels for the first and second winters.

The data available for this study were obtained from cows on Trials IV, V, and VI, which were nursing their third, second and first calves, respectively.

Each level of wintering treatment originally started with fifteen grade, weaner, beef heifers allotted at weaning according to age, body

weight, grade, sire, and dam's average productivity.

All heifers grazed native grass pastures year-long (primarily little bluestem, Indian grass, switch grass, and less desirable annual grasses and weeds), except for those heifers on the Low level which were maintained in dry lot for one month (mid-November to mid-December) each year at the start of the winter feeding period and fed a limited amount of wheat straw. The stocking rate was approximately 6-8 acres per head.

The levels of winter supplemental feed (cottonseed and milo) were varied in such a way as to obtain approximately the following gains from early November to mid-April (approximately 165 days).

First winter as calves:

Low level - no gain during the wintering period
Medium level - 0.5 pound gain per day
High level - 1.0 pound gain per day
Very High level (fourth and fifth trials only) - self-fed a 50 percent concentrate ration for maximum gains.

Second and subsequent winters as bred females:

Low level - 20 percent loss of fall weight to mid-April
Medium level - 10 percent loss of fall weight
High level - no loss in weight
Very High level - same treatment as first winter.

In addition a mineral mixture of two parts of salt and one part of steam bone meal was available to cows at all times.

Supplemental feeding was started early-November and was terminated approximately April 15. The supplements were fed daily.

During the breeding season (approximately May 1 to mid-August), cows were divided into groups on the basis of previous productivity within each nutritional treatment and mated to purebred Hereford bulls from the Experiment Station herd. At the same time, these breeding groups were rotated in the pasture to minimize differences in forage available.

The cows calved first in the late winter and early spring (February 1 st

to May 1st) at approximately two years of age. The calving date, birth weight, and weaning weights of the calves were recorded. Calves were weighed at monthly intervals, while cows were weighed approximately every other month. Calves were weaned in early October as they approached seven months of age.

Bull calves were castrated at six to eight weeks of age and all calves were dehorned and vaccinated for blackleg and malignant edema at approximately three months of age.

A total of five, 24-hour milk production records were obtained in the spring and summer of 1961 from each cow during the early part of April, and June through September. The technique of Howes et al. (1958), Drewry et al. (1959), and Dawson et al. (1960) was used, with certain modifications.

The day previous to the milk estimation, the calves were separated from the cows for 5 to 6 hours before nursing to assure that the cows would be completely nursed out. The nursing the day prior to sampling marked the beginning of the 24-hour collection period (approximately 4 p.m.). The calves were then separated from the cows in an adjacent pen until 5 a.m. the next morning. At this time, the morning milk yields of the cows were estimated by the weight differences of their calves immediately before and after nursing. The same evening (twelve hours later), milk yields were again estimated. The average of the two estimates was taken as the daily milk yield of the cow. The calves were weighed to the nearest 0.25 pound. No samples of milk were secured, hence no correction could be made for the fat content of the milk.

The number of cows on which estimations were obtained by age and level of previous winter feeding is shown on Table I.

The data were analyzed statistically by the methods of Snedecor

(1956). Simple correlations were calculated between the following:

- Average daily milk production and average daily calf gain for the different periods during the lactations.
- Milk production at first sampling and average milk production at subsequent samplings.
- Milk production at first sampling and total calf gain from the first sampling to weaning time.
- Milk production at first sampling and calf age in days from birth to the date of first sampling.

In addition, intra-class correlations were calculated for each level of winter feeding within each trial.

TABLE I

AVERAGE NUMBER OF COWS ON WHICH ESTIMATIONS WERE OBTAINED AT EACH SAMPLING DATE BY AGE AND LEVEL OF PREVIOUS WINTER FEEDING

Age Group	Different Levels of Winter Feeding	Total Observ. Per Age Group	Previous Level of Winter Feeding
Two-yr.-old cows	5	47	1st and 2nd winters on Low-Low, Med.-Med., High-High, Low-High, and High-Low levels, respectively.
Three-yr.-old cows	4	47	Wintered since weaner calves on Low, Medium, High, and Very High levels.
Four-yr.-old cows	4	53	Wintered first 4 years on Low, Medium, High, and Very High levels, with exception of Lot 4 which was reverted during the 4th winter to a Medium level of nutrition.

RESULTS AND DISCUSSION

The average winter weight losses for the three age groups of cows on different winter feeding levels during 1960-1961, expressed as percentage of fall body weight, are shown on Table II. The average birth dates and birth weights of their calves are also included. The typical trend observed for the lactation curves of beef cows, as influenced by different feed levels during the previous winter, are presented in Figure 1. These data show the trend for three-year-old cows.

The average daily milk production of cows and average daily gains of calves, by periods, and correlations between these two measurements for individual and combined periods, appear in Appendix Tables VIII, IX, and X.

Correlations of Average Daily Milk Production of the Cows and Average Daily Weight Gain of Their Calves

The simple correlations obtained between average daily milk production of cows and the average daily gains of their calves for four different lactation periods during the summer are summarized in Table III. The daily milk yield for each period represents the mean of two consecutive observations taken at the beginning and end of each period. The average daily weight gain of the calves corresponds to the difference in body weight at the beginning and end of each period, divided by the number of days elapsing.

TABLE II

PERCENT AVERAGE WINTER WEIGHT LOSS OR GAIN OF FALL WEIGHT OF TWO-, THREE-, AND FOUR-YEAR-OLD COWS AND AVERAGE BIRTH DATE AND BIRTH WEIGHT OF THEIR CALVES

Age Group	Level of Wintering	Percent Weight Loss or Gain	Average Birth Date	Average Birth Weight (lbs.)
Two-year-old cows				
	Low-Low	-22.0	3-27	60.5
	Medium-Medium	-13.3	3-13	65.1
	High-High	- 0.9	3-7	67.2
	Low-High	+ 4.5	3-23	69.4
	High-Low	-27.8	3-2	62.5
Three-year-old cows				
	Low	-16.6	4-4	69.5
	Medium	- 9.0	3-16	73.8
	High	- 7.4	3-1	75.3
	Very High	+ 8.2	3-9	77.0
Four-year-old cows				
	Low	-16.4	3-19	75.7
	Medium	- 8.5	3-9	79.1
	High	- 8.5	3-4	81.7
	Very High-Medium	-21.0	3-3	79.7

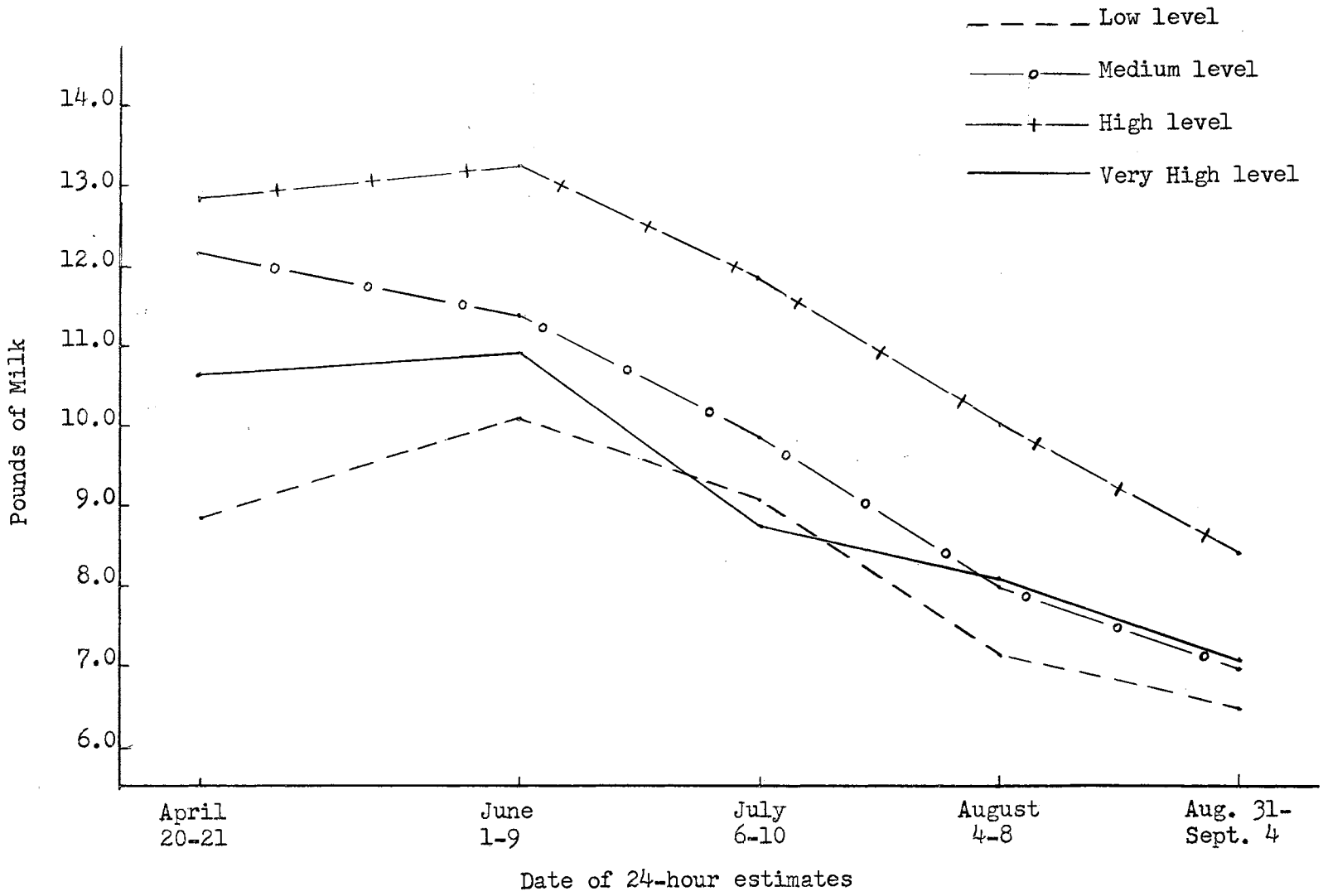

Figure 1. Summer Lactation Curves for Three-year-old Beef Cows Previously Wintered at Different Levels

TABLE III

CORRELATION COEFFICIENTS OF AVERAGE DAILY MILK YIELD AND AVERAGE DAILY CALF GAIN BY PERIODS, AGE OF DAM, AND LEVEL OF WINTER TREATMENT

Age Group	Previous Winter Treatment	PERIODS: April 20-27 to June 1-9	June 1-9 to July 6-10	July 6-10 to Aug. 4-8	Aug. 4-8 to Aug. 31-Sept. 4
Two-year-old cows					
	Low-Low	0.65	0.26	0.17	-0.03
	Medium-Medium	0.89**	0.80*	0.13	-0.18
	High-High	0.54	0.06	0.55	-0.06
	Low-High	0.57	-0.44	-0.01	0.47
	High-Low	0.89**	0.86**	0.75*	-0.05
	Overall	0.69	0.37	0.35	-0.02
Three-year-old cows					
	Low	0.59	0.61	0.26	-0.21
	Medium	0.76**	0.73**	0.81**	0.09
	High	0.61*	0.07	0.53	0.16
	Very High	0.76**	0.01	0.50	0.39
	Overall	0.71*	0.23	0.54	0.16
Four-year-old cows					
	Low	0.76**	0.00	0.08	0.11
	Medium	0.71**	0.22	0.26	0.84**
	High	0.46	0.49	0.27	0.55*
	Very High-Medium	0.31	0.83**	0.37	0.11
	Overall	0.49	0.09	0.27	0.45

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

Overall correlations for all age groups studied where cows were wintered on a Low level of nutrition since weaner calves, were highest for the first period (April 20-27 to June 1-9) and decreased thereafter until a negative correlation of -0.03 and -0.21 for the two-, and three-year-old cows and a positive correlation of 0.11 for the four-year-old cows was observed on the last period before weaning. This might indicate a more persistent lactation among the four-year-old cows. During the first period the correlation of 0.76 was highly significant, but declined during the second and third periods for four-year-old cows, as compared to younger cows wintered on similar planes of nutrition. Velasco (1962) reported correlations of 0.68, 0.57, 0.19, -0.02, and 0.14 for monthly periods extending from mid-May to mid-September, respectively, using four- and five-year-old cows wintered at a Low level and grazing native grass pastures during the summer.

Correlations of 0.89 ($P < 0.01$) and 0.80 ($P < 0.05$), 0.76 and 0.73 ($P < 0.01$), and 0.71 ($P < 0.01$) and 0.22 were obtained for the three age groups of cows on the Medium level during the first and second periods studied. This is in agreement with correlations reported by Gifford (1953) during a similar period of lactation. This lot showed the most consistent pattern in their correlations as compared to any other lot. The low correlation obtained for the Medium level of four-year-old cows during the second period was not expected, since an examination of the data in Appendix Table X shows that it was during this period that these cows reached their peak in milk production and their calves made the highest daily gains. The unusual high value obtained for this same group during the last period is also difficult to explain. A correlation of 0.77 ($P < 0.01$) was reported by Velasco (1962) for the last month of the

suckling period on four- and five-year-old cows wintered on a Low level of nutrition, after obtaining a low correlation of 0.14 for the previous month.

Correlations of milk yield and calf gain for two-year-old cows wintered on the High level were 0.54, 0.06, 0.55, and -0.06, respectively, for the four periods studied. Correlations for the three-year-old cows during the same periods were 0.61 ($P < 0.05$), 0.07, 0.53, and 0.16, and for the four-year-old cows 0.46, 0.49, 0.27, and 0.55 ($P < 0.05$), respectively. While these correlations are rather low, the calves made the greatest daily weight gain of any of the wintering treatments studied. The correlation on the first period of the three-year-old cows was significant at 0.61 ($P < 0.05$), but declined to a low and non-significant value for the fourth month of lactation. However, a positive significant correlation of 0.55 ($P < 0.05$) was obtained for the last period before weaning on the four-year-old cows or the High level. Correlations reported by Velasco (1962) on four- and five-year-old cows were also low during June, and also increased thereafter for the subsequent monthly periods.

The average daily gain of calves from two-year-old cows on the Low-High and High-Low treatments were exactly the same for the overall periods. However, the calves from the last lot appeared to have utilized their dam's milk more efficiently throughout the suckling period, since they received an overall average daily milk yield of 7.35 pounds as compared to 8.60 pounds for calves from cows on the Low-High level (see Appendix Table VIII). Average daily milk production was significantly correlated to calf gain in the High-Low level lot during the first three periods with coefficients of 0.89, 0.86 ($P < 0.01$) and 0.75 ($P < 0.05$); whereas

it was not significant at any period for the Low-High lot. Monthly estimates show a wide difference in amount of milk produced and persistency of lactation between these two lots. Three-year-old cows maintained on a Very High level of nutrition each winter for three years prior to this study were apparently depressed in their milk yields due to the level of feeding imposed upon them, as compared to cows wintered at the Medium level. However, their calves made as good daily gains and appeared to utilize milk more efficiently, on the average, over the entire suckling period than the calves from the Medium level cows. A highly significant correlation of 0.76 ($P < 0.01$) was obtained for the first period, followed by a very low correlation of 0.01 for the second sampling period.

The correlation of milk yield and calf gain for four-year-old cows on the Very High level for three consecutive years and then reverted during the winter immediately preceeding this study to a Medium level, was low during the first sampling period, but increased to a highly significant value of 0.83 ($P < 0.01$) for the third to fourth months of lactation.

Average daily milk production for each period was on the average more than two pounds higher in this study than the values reported by Gifford (1953) on cows of varying ages, but it is in agreement in that two- and three-year-old cows produced lower milk yields than four-year-old cows. Also, average daily gains of calves tend to increase with age, even though milk yields declined.

In general, the correlations obtained in this study were higher during the early period of milk yield and calf growth, decreasing during each succeeding period. However, there was considerable variation in

correlations obtained between age of dam, periods, and levels of wintering. Age differences of calves among the treatments and age of dam groups may have contributed to the erratic nature of some of the correlations. As age of the cow increased, there appeared to be a higher dependence of the calf on milk during the last period before weaning, as suggested by the relatively large overall correlations for this period.

Average daily gains of calves and daily milk production of two- and three-year-old cows on the Low level lots were high for the first period studied, but not significantly correlated. The same was true for two-year-old cows wintered on a Low-High feeding level. Thereafter, the correlations decreased as lactation progressed. On the contrary, calves from four-year-old cows wintered on a Low level of nutrition, made gains highly dependent on the milk of their dams for the first period, but decreased to a low value for the subsequent periods.

Gains of calves from cows wintered on a Medium level of nutrition appeared to be highly correlated to average daily milk production during the first four months of the suckling period, decreasing thereafter to a low correlation at weaning. For the High level winter treatment of each of the three different age groups, correlations were relatively low for the first period as compared to cows on a Medium level, or as judged by the milk yield obtained at the different sampling periods.

Calf gain appeared to be highly correlated with milk produced by three-year-old cows wintered at the Very High level during the first sampling period, but this dependence declined almost to zero for the following period and thereafter increased slightly for the third and fourth periods. Gains of calves from four-year-old cows wintered on a Very High level for three winters and then reverted to a Medium level for

the fourth winter were significantly correlated to milk production of their dams.

Correlation of First Estimation of Milk Yield to Calf Age, Subsequent Milk Yield and Calf Gain

Since milk production of the cow has such an important effect upon growth of the calf, an attempt was made to establish a relationship between an early estimate of milk production, taken at approximately six weeks after parturition, and subsequent milk yield. Also, the relationship of such an estimate to calf gain during the remainder of the suckling period, was investigated. This first estimate would serve as a basis for predicting, depending on certain environmental factors, the milk yield and subsequent calf gain during the remainder of the lactation period.

The yield of this first estimate depends on several factors. Among these are: (a) Time of calving, which determines the stage of lactation or peak of production; (b) the ability of the calf to consume all the milk produced; (c) the plane of nutrition to which the dam has been exposed as it influences her milk producing ability and the vigor and development of her calf; and (d) the errors involved in obtaining an accurate milk yield of beef cows.

Relationship of Amount of Milk Obtained at the First Sample and Age of Calf: Since this sample is taken in the rising phase, or near the peak, of the lactation curve, it is to be expected that as age of the calf increases, daily milk production will also increase up to a point. This results in a positive relationship between these two factors. However, if the cow passes the peak of lactation and is declining in milk production

at the time the first sample is taken, then, as the age of calf increases, daily milk production will decrease. This will result in a negative relationship. However, the relationship may not be as clear cut as this since beef cows may not show maximum production early in the lactation curve if their calves do not consume all the milk (Gifford, 1953) or if milk yield is influenced by previous plane of nutrition of the cow. Individual variation among cows and their response to treatment may result in different lactation curves.

Simple correlations between the first milk estimation and age of calf at the time of this estimation was made are presented in Table IV. In general, the correlations do not appear to follow a definite pattern or trend among the age groups studied for different levels of nutrition. In general, however, calf age and milk yield tended to be negatively correlated. This trend was most apparent among the two-year-old and four-year-old cows.

As the cows increased in age, there may have been an earlier peak in milk production. This, together with the earlier calving date for High level wintered cows, may have been the reason for the significant negative correlations obtained.

Overall correlations, for all cows within an age group and all levels included, were -0.11, -0.33, and -0.52 for two-, three-, and four-year-old cows, respectively. This further reflects the trend toward a larger negative correlation with an increase in calf age. The data indicate that calf age, as it may reflect the stage of lactation of the dam, must be considered in comparing the effect of different winter treatments, or age of dam, on milk yield.

Correlation of First Estimation and Subsequent Milk Production: A first

TABLE IV

FIRST MILK YIELD ESTIMATE[1] OF TWO-, THREE-, AND FOUR-YEAR-OLD COWS, AGE OF THEIR CALVES FROM BIRTH TO THIS ESTIMATE, AND CORRELATION BETWEEN THE TWO MEASUREMENTS

Age Group	Level of Wintering	Number of Observations	First Milk Estimate (lbs.)	Standard Error of Mean	Calf Age (days)	Standard Error of Mean	Correlation Coefficient
Two-year-old cows							
	Low-Low[2]	9	9.75	± 0.82	31.8	± 4.17	0.02
	Medium-Medium	8	9.68	± 0.88	45.2	± 7.08	-0.22
	High-High	9	9.80	± 0.50	58.3	± 5.91	-0.83**
	Low-High	9	10.80	± 0.43	40.5	± 4.59	0.13
	High-Low	9	8.27	± 0.83	54.6	± 3.90	0.47
	Overall	8	9.65	± 0.50	46.1	± 2.80	-0.11
Three-year-old cows							
	Low	7	8.96	± 0.60	23.8	± 6.81	0.04
	Medium	12	12.14	± 1.18	40.0	± 3.79	-0.79**
	High	13	12.84	± 0.76	51.3	± 3.55	0.17
	Very High	10	10.75	± 0.78	52.4	± 3.80	-0.16
	Overall	10	11.45	± 0.53	43.7	± 2.57	-0.33
Four-year-old cows							
	Low	11	10.72	± 0.85	33.3	± 4.17	-0.72*
	Medium	12	11.50	± 0.87	48.0	± 3.59	-0.55
	High	14	12.42	± 0.96	47.6	± 5.06	-0.56*
	Very High-Medium	14	11.08	± 0.70	47.9	± 3.57	-0.29
	Overall	13	11.75	± 0.43	44.7	± 2.27	-0.52

[1]Obtained on April 20 to 27.
[2]Level of winter feeding the first and second years, respectively.
[3]Level of winter feeding the first three years and the fourth year, respectively.
*$P < 0.05$
**$P < 0.01$

sample, taken at the peak of production, reflects subsequent milk yield for the remainder of lactation. The question arises as to how are the two associated and whether or not subsequent production can be measured in the beef cow from an early sample.

Subsequent milk production is influenced markedly by the winter plane of nutrition, since lower levels may place the cow in a poor physical state to meet the demands of lactation. Also, the amount and quality of the summer pasture and other environmental conditions will greatly affect milk yield.

Simple correlations between the first milk estimation and the average of four subsequent estimations within level of wintering and age groups of females, are summarized in Table V. Two- and three-year-old cows wintered on a Low plane of nutrition since weaner calves showed a correlation of 0.40 and 0.27, respectively, between the first and subsequent estimations. These values are rather expected for cows of this age since they calved in late winter and early spring; hence they were under influence of the plane of nutrition the previous winter at the time the first sample was taken. However, with advancing age of the cows, it is possible that the winter plane of nutrition was not as severe as with young cows. Thus, the four-year-old cows showed a significant correlation of 0.70 ($P < 0.05$) between the first and subsequent milk samples. Also, these cows may have been more consistent in their lactation as observed on their monthly yields, although they were lower than the Medium and High level cows of the same age.

The first yield estimation and the average of subsequent estimations were significantly correlated by 0.89, 0.76, and 0.74 ($P < 0.01$) for two-, three-, and four-year-old cows, respectively, subjected to the Medium

TABLE V

FIRST MILK YIELD ESTIMATE OF TWO-, THREE-, AND FOUR-YEAR-OLD COWS, AVERAGE OF SUBSEQUENT MILK ESTIMATES, AND CORRELATION BETWEEN THE TWO MEASUREMENTS[1]

Age Group	Level of Wintering	Number of Observations	First Milk Estimate (lbs.)	Standard Error of Mean	Average Subsequent Estimates (lbs.)	Standard Error of Mean	Correlation Coefficient
Two-year-old cows							
	Low-Low[2]	9	9.75 ± 0.82		7.82 ± 0.44		0.40
	Medium-Medium	8	9.68 ± 0.88		7.77 ± 0.95		0.89**
	High-High	9	9.80 ± 0.50		7.56 ± 0.67		0.82**
	Low-High	9	10.80 ± 0.43		7.95 ± 0.33		-0.03
	High-Low	9	8.27 ± 0.83		7.06 ± 0.60		0.83**
	Overall	8	9.65 ± 0.50		7.63 ± 0.28		0.65
Three-year-old cows							
	Low	7	8.96 ± 0.60		7.88 ± 0.51		0.27
	Medium	12	12.14 ± 1.18		9.05 ± 0.90		0.76**
	High	13	12.84 ± 0.76		11.15 ± 0.74		0.64*
	Very High	10	10.75 ± 0.78		7.87 ± 1.07		0.56
	Overall	10	11.45 ± 0.53		9.22 ± 0.47		0.63*
Four-year-old cows							
	Low	11	10.72 ± 0.85		8.84 ± 0.65		0.70*
	Medium	12	11.50 ± 0.87		9.97 ± 0.87		0.74**
	High	14	12.42 ± 0.96		10.35 ± 1.06		0.84**
	Very High-Medium[3]	14	11.08 ± 0.70		9.35 ± 0.78		0.49
	Overall	13	11.75 ± 0.43		9.66 ± 1.40		0.71**

[1]First milk estimate was obtained on April 20 to 27 and subsequent milk estimates on June 1 to 9, July 6 to 10, August 4 to 8, and August 31 to September 4.

[2]Level of winter feeding the first and second years, respectively.

[3]Level of winter feeding the first three years and the fourth year, respectively.

*$P < 0.05$

**$P < 0.01$

planes of winter nutrition. Cows of the same age groups, but wintered at a High level since weaner calves, were also highly consistent in their yields later in lactation; the corresponding correlations for the three different ages were 0.82 ($P < 0.01$), 0.64 ($P < 0.05$), and 0.84 ($P < 0.01$), respectively. Cows on these two levels, Medium and High, might tend to have a high or more persistent yield for the rest of the lactation, as observed by their milk production yields, than other cows carried at a Low level, hence the higher correlations. The first sample accounted for 42 to 58 percent of the variation in milk yields at subsequent samplings. Therefore, it seems that a first milk sample from cows wintered at Medium and High levels of nutrition may well reflect her ability to produce milk for the remainder of lactation. Cows so wintered may be better prepared for lactation at that period than those wintered at lower levels.

Two-year-old cows wintered on Low or High level the first year and then changed the second winter to the opposite level showed a negative correlation of -0.03 and a positive of 0.83 ($P < 0.01$) for the Low-High and High-Low lots, respectively. The correlation of the Low-High level lot is difficult to explain in view of the above discussion. The poor correlation with the High-Low treatment is possibly due to cows being physiologically more developed than those carried on the Low-High level. Also, their calves were dropped early when new grass was not yet available, therefore the first sample was low as compared to the average of subsequent milk samples. This was perhaps the reason for obtaining such a high correlation for this lot. It also could be that cows recouperated considerably when grass became available, resulting in high yields later in lactation as compared to the first estimate, causing a high correlation.

Low and non-significant correlations were obtained for the three-year-old cows wintered since weaner calves on a Very High level, and also for four-year-old cows on a Very High level for three years and then reverted to a Medium level the winter prior to sampling for milk production. Among the latter group, although the cows produced higher yields at first and subsequent estimations than the Low level lot of the same age, a correlation of 0.49 was obtained as compared to a significant correlation of 0.70 for the Low level. This may have occurred due to the winter feeding level during previous years which depressed milk production the following year on a Medium level, or because such cows, going into the winter in fleshy condition, lost weight excessively (see Table II).

In addition, it can be observed in Table V that, as cows on the Low, Medium, and High planes of nutrition grow older, the correlation between the two measurements tends to be higher on the overall for each age group. Overall correlations for all levels of feeding combined were 0.65, 0.63 ($P < 0.05$) and 0.71 ($P < 0.01$) for the two-, three-, and four-year-old cows, respectively, showing a higher association of the first sample with subsequent production for all ages as the cows grow older.

In conclusion, the first milk estimation obtained from two-, three-, and four-year-old cows wintered on a Medium or High level of nutrition was highly correlated to the average of subsequent estimations. Therefore, by obtaining a milk estimation early in lactation and taking into consideration the previous level of winter nutrition, subsequent milk yield can be predicted with a certain degree of confidence, providing the summer environment is adequate for optimum milk yield.

In relation to two-year-old cows wintered on a High-Low level or the reverse for the first two winters, unexplainable correlations were obtained.

Further trials would be necessary to show more clearly whether or not the correlation can be so influenced by Low-High levels, since no apparent explanation for this effect is now available.

Cows on the Very High and Very High-Medium reverted levels of nutrition seem to be depressed in their subsequent milk production because of the level of feeding imposed upon them during winter as compared to those on Medium and High levels throughout. This depression in milk production resulted in low correlations between the first estimate and the average of subsequent milk estimates.

Correlation of First Estimate and Subsequent Calf Gain: It has been shown that a high correlation exists between average daily milk production and average daily gain of the calf, and also that first and subsequent milk estimations are highly correlated for properly wintered females. Hence, it was desirable to relate the first estimate, taken early in lactation, to the subsequent gain of the calf.

Several factors influence calf gains during the suckling period. Among these are: (a) Inherent capacity for growth; (b) environment during the summer pasture season; (c) cow's persistency of lactation; and (d) errors involved in accurately measuring calf gain and milk production. Nevertheless, since milk is so important for growth in early life, it is desirable to establish the relationship between a single estimate taken early in lactation and subsequent calf gain up to weaning.

The total gain in weight of the calf from date of first milk estimation until weaning, early in October, comprised the calf gain. Weights of calves were corrected for age and sex at weaning.

Data on yield at first milk estimation and calf gain with the corresponding correlation between these two measurements appear on Tavle VI.

TABLE VI

FIRST MILK YIELD ESTIMATE[1] OF TWO-, THREE-, AND FOUR-YEAR-OLD COWS, WEIGHT GAIN OF THEIR CALVES FROM THE DATE OF FIRST MILK ESTIMATION TO WEANING, AND CORRELATION BETWEEN THE TWO MEASUREMENTS

Age Group	Level of Wintering	Number of Observations	First Milk Estimate (lbs.)	Standard Error of Mean	Calf Gain (lbs.)	Standard Error of Mean	Correlation Coefficient
Two-year-old cows							
	Low-Low[2]	9	9.75	± 0.82	295.6	± 7.01	0.51
	Medium-Medium	8	9.68	± 0.88	293.6	± 14.50	0.64
	High-High	9	9.80	± 0.50	279.0	± 13.56	0.91**
	Low-High	9	10.80	± 0.43	297.8	± 9.32	-0.54
	High-Low	9	8.27	± 0.83	268.6	± 9.84	0.66*
	Overall	8	9.65	± 0.50	286.8	± 5.31	0.52
Three-year-old cows							
	Low	7	8.96	± 0.60	322.4	± 12.25	0.31
	Medium	12	12.14	± 1.18	328.1	± 11.97	0.73**
	High	13	12.84	± 0.76	318.3	± 12.83	0.33
	Very High	10	10.75	± 0.78	302.8	± 12.85	0.84**
	Overall	10	11.45	± 0.53	318.1	± 6.61	0.53
Four-year-old cows							
	Low	11	10.72	± 0.85	329.6	± 11.70	0.86**
	Medium	12	11.50	± 0.87	326.0	± 9.01	0.69*
	High	14	12.42	± 0.96	324.0	± 15.18	0.72**
	Very High-Medium	14	11.08	± 0.70	313.2	± 9.68	0.29
	Overall	13	11.75	± 0.43	322.7	± 5.87	0.64*

[1]Obtained on April 20 to 27.
[2]Level of winter feeding the first and second years, respectively.
[3]Level of winter feeding the first three and the fourth year, respectively.
*$P < 0.05$
**$P < 0.01$.

Gains of calves from two-year-old cows wintered on a Low and Medium level were correlated by 0.51 and 0.64, respectively, but not high enough to be significant, although on the Medium level lot the first milk estimate was highly correlated to the average of subsequent estimates by 0.89 ($P < 0.01$). The correlation for the High level cows of this younger group was highly significant with 0.91 ($P < 0.01$) and in agreement with the one obtained for first and average of subsequent estimations. This reflects the ability of well fed cows to produce sufficient milk for optimum calf growth for the remainder of the suckling period. A negative correlation between the two measurements was obtained for the Low-High level treatment, which is in agreement with that obtained for first and subsequent estimations. There is no apparent explanation for this discrepancy with the correlations obtained for the Low-Low or High-Low lots, other than a sampling error. The correlation between first milk estimate and subsequent calf gain made by calves from cows on a High-Low plane of nutrition was significant with 0.66 ($P < 0.05$), agreeing with the value obtained for first milk estimate and average of subsequent estimates for the same feeding level lot.

The correlation for the Low level lot from the three-year-old cows is even lower than the one obtained for two-year-old cows wintered on the same treatment, but it is in agreement with the value obtained between first and average of subsequent estimations. Calves from three-year-old cows fed on a Medium level made gains highly correlated to first milk estimation, value which agrees with the correlation made between first milk estimation and average of subsequent estimations. The value of 0.33 obtained for the High level lot is rather low, since first estimate was significantly correlated to the average of subsequent estimates by 0.64

($P < 0.05$). On the contrary, calves from cows on the Very High level made gains significantly correlated by 0.84 ($P < 0.01$) to the first estimation, although a drop in subsequent milk production observed in this lot resulted in a non-significant correlation of 0.56 between the first and average of subsequent milk yield samples.

Correlations between first milk estimate and subsequent calf gain for the four-year-old group were higher and more consistent with those obtained between first and average of subsequent estimations for the Low, Medium, and High lots. It is of interest that an increase in age of dam from three to four years caused a highly significant correlation between calf gain and first sampling, while such correlations were quite low at three years of age for similar levels of wintering.

The correlation between first and average of subsequent estimations in the older age group for the Very High lot reverted to Medium was low, as was observed previously for the three-year-old cows, and the value for first milk estimation and calf gain resulted in even lower correlations.

In conclusion, it appears that, on the average, subsequent gains of calves from two-year-old cows, wintered at Medium level, are consistent in their correlation with first milk estimation from three-year-old cows wintered on the same levels. In comparing correlations between first milk estimation and subsequent calf gain with correlations obtained between first and subsequent milk estimations for two- and three-year-old cows, they agree in general, except that three-year-old cows wintered on High and Very High levels of feeding gave very contrasting values. These two correlations were in good agreement for the four-year-old group under different levels of feeding. This would indicate that as the cow grows older, a milk estimation made early in lactation at this age may

give an approximate indication of how well she may lactate for the rest of the suckling period, as well as to the probable gains of her calf, since the calf is so dependent on milk production for rapid gains. It is realized that the number of observations per treatment is too low to draw definite conclusions from the results obtained. This is particularly true of younger cows which raised fewer calves than those on older groups.

Similarly, if a particular lot of cows proves to be a poor sample relative to the amount of milk given at the time of the first estimate, this poor sample will affect all correlations which are calculated on first estimate as a variable.

Considering the three phases discussed above, it would appear that age of calf and first milk yield estimation did not show a definite trend in their correlations within wintering levels of the dam. On an overall basis, as age increased the correlation became more and more negative, denoting an earlier peak taking place before this milk estimation was made.

A first milk sample taken on two- and three-year-old cows wintered on a Low and Low-High level seemed to be a very poor indicator of both subsequent milk yields and calf gains. On the contrary, this first sample was a good indicator of subsequent performance in lactation on four-year-old cows wintered on a Low level.

In general, the first milk sample from two-, three-, and four-year-old cows wintered at Medium and High levels appeared to give a good indication of subsequent milk production and gains of their calves. The same was true for two-year-old cows wintered on a High and Low plane the first and second winters.

Large discrepancies in the correlations between the Low-High and High-Low level lots were common throughout all aspects of the study relative to first milk estimation. Further trials will be necessary to show whether or not such extreme values between the two lots are indeed an effect of treatment.

Three-year-old cows wintered at the Very High level seemed to be depressed in persistency of milk production by the wintering regime imposed. This appeared to adversely affect subsequent milk production, resulting in non-significant correlations in relation to first milk sample, although this sample was highly correlated to subsequent calf gain. A first milk estimate, taken from four-year-old cows wintered on a Very High level the first three years and then reverted to a Medium level the fourth year, was a poor indicator of subsequent milk yield and calf gain.

Repeatability of Milk Production of Beef Cows from Samples Taken During a Lactation Period

The purpose of this phase of the study is to find out the relationships existing among different milk estimates within a single lactation period from cows previously wintered on a particular level of feeding.

The relationships among milk estimates depend mainly on two factors: (a) the genetic variation among cows treated alike in their ability to produce milk and (b) the environmental conditions affecting the cows at the time the milk samples are taken. A large intra-class correlation indicates that cows tend to repeat their relative rank in amount of milk produced and a small correlation indicates a low repeatability.

Individual correlations by level of wintering and age of dam, are presented in Table VII. Cows previously wintered at a Low level showed

a marked increase in correlation among milkings at four years of age as compared to younger cows; coefficients were 0.31, 0.35, and 0.62 ($P < 0.05$) for two-, three-, and four-year-old cows, respectively. This agrees with results obtained for previously determined simple correlations. Then as the cow grows older, her production tends to be more consistent, resulting in higher correlations between samplings.

TABLE VII

VARIANCE IN MILK YIELDS AS MEASURED BY INTRA-CLASS CORRELATION BY LEVEL OF WINTER FEEDING AND AGE OF COWS

Age Group	Level of Wintering	Number of Observations	Correlation Coefficient[1]
Two-year-old cows			
	Low-Low	9	0.31
	Medium-Medium	8	0.83**
	High-High	9	0.51
	Low-High	9	0.16
	High-Low	9	0.65
Three-year-old cows			
	Low	7	0.35
	Medium	12	0.61*
	High	13	0.40
	Very High	10	0.63*
Four-year-old cows			
	Low	11	0.62*
	Medium	12	0.76**
	High	14	0.89**
	Very High-Medium	14	0.68**
Overall intra-class correlation			0.66*

[1]Significance was determined from Table 7.6.1, Snedecor (1956).
*$P < 0.05$
**$P < 0.01$

Cows at the Medium level of nutrition showed an intra-class correlation of 0.83 ($P < 0.01$), 0.61 ($P < 0.05$), and 0.76 ($P < 0.01$) among milk estimates, for the three age groups, respectively. This is the most

consistent lot in their correlations when all levels at all ages are compared.

Correlation coefficients of 0.51, 0.40, and 0.89 ($P < 0.01$) were obtained for the two-, three-, and four-year-old cows previously wintered at the High level, respectively. A lower significantly different value was obtained for the three-year-old cows as compared to the two-year-old cows; this may be due to a higher rate of decline in milk yields among these cows.

Two-year-old cows wintered on a Low-High level had the lowest correlation of all levels and ages, reflecting either a depression on consistency of milk yield due to wintering level as compared to Low-Low cows of the same age, or more likely due to a bad sampling in obtaining milk yields from these cows. A high but not significant correlation of 0.65 was obtained for the High-Low lot, reflecting a rather small variation in yield between milkings at this early age.

Among three-year-old cows, wintered on a Very High level of nutrition since weaner calves, a significant correlation of 0.63 ($P < 0.05$) was obtained. When cows on this level of nutrition were wintered the fourth year on a Medium level, it resulted in a highly significant correlation of 0.68 ($P < 0.01$). In contrast, simple correlations using the first milk sampling as a variable and subsequent milk production or calf gain as the other variable, resulted in a lower correlation for the four-year-old group than in the three-year-old group.

The overall intra-class correlation obtained, when levels of winter feeding and age groups were combined, was 0.66 ($P < 0.05$).

In summary, as the age of the cows increased, a higher repeatability estimate was obtained for the relative amount of milk produced among the

five estimates for all levels.

Two-, three-, and four-year-old cows fed on a Medium level of nutrition the winter previous to the sampling appeared to be more consistent in estimations of milk yield within a lactation. This is indicated by the high intra-class correlations obtained for this treatment among the age groups studied.

In general, the first milk estimate used in the earlier part of this study to predict subsequent milk production or calf gain, for cows wintered on a Medium level of feeding, is a reliable value since the milk yield appears to be highly repeatable. Except for the Low and Medium level cows of the three different age groups studied, estimates from cows on other feed levels did not seem to follow the same trend as the intra-class correlation when a first estimate was related to subsequent milk production and calf gain.

SUMMARY

Milk production studies involving 47, 47, and 53 two-, three-, and four-year-old Hereford cows, respectively, were conducted during the summer of 1961 to investigate certain relationships between milk production of the dam and the weight gain of her suckling calf. Within each age group, the cows had been subjected to different planes of nutrition the previous winter. Among the relationships studied were: (a) Daily milk yield of the dam and average daily gain of the calf, by sampling periods; (b) correlation of a single milk estimate taken in early lactation with the age of the calf, subsequent milk yield of the dam, and subsequent calf gain; and (c) repeatability of high or low milk production among beef cows by intra-class correlations (within-cow basis) during the lactation period. Five, 24-hour milk production estimates at about monthly intervals were obtained on all cows, during the summer grazing season, in each of the three age groups. Milk yield was determined by the difference in body weight of the calves immediately before and after nursing, twice daily.

In general, the correlations obtained for average daily milk yield and average daily gain of the calves were higher during the first period of lactation studied, decreasing during each succeeding period. Among cows wintered at a Medium level, the correlations obtained for these items were highly significant during the first four months of lactation, decreasing thereafter as lactation progressed. Relatively low and non-

significant correlations were obtained for milk production and calf gain for the first period for two- and three-year-old cows previously wintered on a Low and High level. On the contrary, daily milk of three-year-old cows wintered at a Very High level was highly correlated ($r = 0.76$) to daily gain of their calves, but this value decreased almost to zero for the following period. Overall correlations for the four different periods studied by age group were: 0.69, 0.37, 0.35 and -0.02 for two-year-old cows; 0.71 ($P < 0.05$), 0.23, 0.54, and 0.16 for three-year-old cows; and 0.49, 0.09, 0.27, and 0.45 for four-year-old cows, respectively.

Correlations of age of calf and first estimate of milk yield failed to show a definite trend when analyzed on a within winter treatment of the dam basis. In general, as the age of the cow increased, the correlations became more negative, possibly denoting an earlier peak of lactation before this first milk estimate was obtained. A first milk sample from two-, three-, and four-year-old cows wintered at a Medium or High level appeared to give a good indication of subsequent milk production and calf gain; in two- and three-year-old cows, previously wintered at a Low level, the first milk estimate proved to be a poor indicator.

Repeatability estimates of the relative rank of females in terms of amount of milk produced during five estimates, as measured by intra-class correlations, resulted in significant values of 0.83 ($P < 0.01$), 0.61 ($P < 0.05$), and 0.76 ($P < 0.01$) among two-, three-, and four-year-old cows, respectively, wintered at a Medium level. Three-year-old cows previously wintered on a Very High level showed a significant correlation of 0.63. When cows on this level of nutrition were reverted during the fourth year to a Medium level, a highly significant correlation of 0.68

was obtained. Higher repeatability estimates were common for all levels of nutrition among four-year-old cows as compared to younger cows.

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A P P E N D I X

TABLE VIII

CORRELATIONS OF DAILY MILK YIELD OF TWO-YEAR-OLD COWS AND AVERAGE DAILY WEIGHT GAIN OF THEIR CALVES BY PERIODS

Level of Wintering	April 27 to June 1-9	June 1-9 to July 6-10	July 6-10 to Aug. 4-8	Aug. 4-8 to Aug. 31-Sept. 4	Average for all Periods
Low-Low					
Number of Cows	9	10	10	10	9
Average Daily Milk Production	9.66±.63	8.98±.47	8.06±.44	6.99±.54	8.39±.31
Average Daily Calf Gain	1.50±.26	1.64±.01	1.63±.01	1.74±.01	1.63±.03
Correlation Coefficient	0.65	0.26	0.17	-0.03	0.31
Medium-Medium					
Number of Cows	7	7	8	8	7
Average Daily Milk Production	10.17±.19	9.51±1.31	7.57±.90	6.45±.86	8.35±.60
Average Daily Calf Gain	1.67±.33	1.68±.36	1.73±.35	1.75±.89	1.71±.05
Correlation Coefficient	0.89**	0.80*	0.13	-0.18	0.52
High-High					
Number of Cows	9	10	10	10	9
Average Daily Milk Production	9.53±.81	8.23±.73	7.54±.55	6.93±.55	8.02±.37
Average Daily Calf Gain	1.76±.42	1.79±.03	1.59±.02	1.74±.03	1.72±.05
Correlation Coefficient	0.54	0.06	0.55	-0.06	0.20
Low-High					
Number of Cows	9	10	10	10	9
Average Daily Milk Production	10.44±.34	9.17±.42	7.84±.38	7.16±.37	8.60±.28
Average Daily Calf Gain	1.58±.72	1.70±.01	1.66±.01	1.77±.02	1.68±.03
Correlation Coefficient	0.57	-0.44	-0.01	0.47	0.38
High-Low					
Number of Cows	9	8	8	9	8
Average Daily Milk Production	8.41±.60	8.20±.67	6.84±.86	6.01±.71	7.35±.40
Average Daily Calf Gain	1.48±.86	1.67±.67	1.88±.99	1.77±.63	1.68±.05
Correlation Coefficient	0.89**	0.86**	0.75*	-0.05	0.64

Table VIII (Continued)

Level of Wintering	April 27 to June 1-9	June 1-9 to July 6-10	July 6-10 to Aug. 4-8	Aug. 4-8 to Aug. 31-Sept. 4	Average for all Periods
Overall Average for Each Period					
Number of Cows	8	9	9	9	
Average Daily Milk Production	9.62±.34	8.80±.33	7.60±.28	6.73±.28	
Average Daily Calf Gain	1.60±.04	1.70±.03	1.69±.12	1.74±.03	
Correlation Coefficient	0.69	0.37	0.35	-0.02	

*P < 0.05
**P < 0.01

TABLE IX

CORRELATIONS OF DAILY MILK YIELDS OF THREE-YEAR-OLD COWS AND AVERAGE DAILY WEIGHT GAIN OF THEIR CALVES BY PERIODS

Level of Wintering	April 20-21 to June 1-9	June 1-9 to July 6-10	July 6-10 to Aug. 4-8	Aug. 4-8 to Aug. 31-Sept. 4	Average for all Periods
Low					
Number of Cows	7	8	9	10	8
Average Daily Milk Production	9.56±.64	9.34±.63	7.92±.58	6.79±.54	8.23±.36
Average Daily Calf Gain	1.51±.97	1.65±.85	1.75±.78	1.74±.01	1.67±.05
Correlation Coefficient	0.59	0.61	0.26	-0.21	0.35
Medium					
Number of Cows	12	12	12	12	12
Average Daily Milk Production	11.74±1.12	10.59±.98	8.91±.82	7.50±.76	9.69±.52
Average Daily Calf Gain	1.78±.10	1.92±.56	1.78±.58	1.98±.31	1.86±.04
Correlation Coefficient	0.76**	0.73**	0.81**	0.09	0.56
High					
Number of Cows	13	13	13	11	12
Average Daily Milk Production	12.99±.64	12.51±.76	10.91±.76	8.88±.61	11.42±.42
Average Daily Calf Gain	1.97±.73	2.13±.61	1.99±.60	1.92±.02	2.03±.04
Correlation Coefficient	0.61*	0.07	0.53	0.16	0.34
Very High					
Number of Cows	10	12	12	12	11
Average Daily Milk Production	10.46±.91	9.85±1.14	8.36±1.18	7.59±1.12	9.00±.58
Average Daily Calf Gain	1.79±.01	1.91±.03	1.84±.76	1.87±.31	1.86±.05
Correlation Coefficient	0.76**	0.01	0.50	0.39	0.36
Overall Average for Each Period					
Number of Cows	10	11	11	11	
Average Daily Milk Production	11.44±.49	10.72±.51	9.14±.49	7.70±.42	
Average Daily Calf Gain	1.80±.05	1.93±.04	1.85±.04	1.88±.05	
Correlation Coefficient	0.71*	0.23	0.54	0.16	

*P < 0.05
**P < 0.01

TABLE X

CORRELATIONS OF DAILY MILK YIELD OF FOUR-YEAR-OLD COWS AND AVERAGE DAILY WEIGHT GAIN OF THEIR CALVES BY PERIODS

Level of Wintering	April 20-21 to June 1-9	June 1-9 to July 6-10	July 6-10 to Aug. 4-8	Aug. 4-8 to Aug. 31-Sept. 4	Average for all Periods
Low					
Number of Cows	11	12	12	12	11
Average Daily Milk Production	11.04±.76	10.77±.80	9.03±.72	7.86±.75	9.64±.43
Average Daily Calf Gain	1.71±.05	2.00±.58	1.80±.67	1.85±.31	1.86±.04
Correlation Coefficient	0.76**	0.00	0.08	0.11	0.18
Medium					
Number of Cows	12	13	12	12	12
Average Daily Milk Production	11.80±.83	12.15±.86	10.19±1.00	9.36±1.17	10.78±.51
Average Daily Calf Gain	1.84±.59	2.01±.59	1.83±.77	1.91±.86	1.90±.04
Correlation Coefficient	0.71**	0.22	0.26	0.84**	0.53
High					
Number of Cows	14	14	14	13	13
Average Daily Milk Production	12.32±1.02	11.87±1.09	10.39±1.11	8.31±1.08	10.77±.58
Average Daily Calf Gain	1.85±.65	2.02±.39	1.91±.03	1.92±.03	1.92±.05
Correlation Coefficient	0.46	0.49	0.27	0.55*	0.42
Very High-Medium					
Number of Cows	13	13	14	14	13
Average Daily Milk Production	11.43±.67	10.80±.84	9.23±.85	7.73±.80	9.75±.44
Average Daily Calf Gain	1.71±.09	1.87±.02	1.77±.70	1.95±.55	1.83±.04
Correlation Coefficient	0.31	0.83**	0.37	0.11	0.42
Overall Average for Each Period					
Number of Cows	12	13	13	12	
Average Daily Milk Production	11.68±.43	11.30±.46	9.72±.48	8.29±.49	
Average Daily Calf Gain	1.78±.04	1.97±.04	1.83±.03	1.93±.03	
Correlation Coefficient	0.49	0.09	0.27	0.45	

*P < 0.05
**P < 0.01

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