THE INFLUENCE OF WINTER NUTRITION ON THE GROWTH AND MILK PRODUCTION OF HEREFORD FEMALES AND THE BIRTH DATE AND GROWTH OF THEIR CALVES

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CHAPTER I

INTRODUCTION

Except in periods of extreme drought, the nutrient intake of the beef female is usually lower in winter than during the summer grazing season. Therefore, the plane of winter nutrition may be one of the major factors affecting the growth and productivity of beef females and the efficiency of a cow-calf operation.

The plane of winter nutrition which will result in proper development of the beef female, maximum reproductive performance and maximum milk production and calf weaning weight is difficult to define. A level of nutrition which results in rapid gain and growth in the development stage may, in fact, be detrimental to subsequent production.

Several research studies have shown that winter nutrition of the dam can affect growth and production criteria (Joubert, 1954; Pinney, 1962; Bond and Wiltbank, 1970). However, very few studies have included the long-term cumulative effects of winter nutrition of the beef female on growth and development, lactation, and pre-weaning performance of offspring. Also, very little information is available on the effects of very high planes of nutrition on the performance of the beef female.

The present study was conducted to determine the cumulative effects of various planes of winter supplemental feed on the growth and development and milk production of Hereford range females and the pre-weaning performance of their calves. The effects of age of dam and birth date and sex of calf on milk production and calf growth were also investigated.

CHAPTER II

LITERATURE REVIEW

Introduction

Several workers have reviewed the literature pertaining to the effects of plane of nutrition on livestock females to include growth, reproductive performance and performance of offspring (Zimmerman, 1958; Zimmerman, 1960; Holland, 1961; Arnett, 1963; Pinney, 1963). Other workers have summarized the results of experiments with laboratory animals (Reid, 1960; Pinney, 1962; Arnett, 1963). This review will encompass the more recent and pertinent research dealing with the effects of plane of nutrition on beef cattle, dairy cattle and sheep.

Research workers have used several criteria to measure the effects of various levels of nutrition on livestock females. Some of these criteria are changes in body weight with emphasis on gains and losses in winter and summer, skeletal development, age and size at puberty, conception rate, birth weight of offspring, percent of females producing offspring, average daily gain of offspring, weaning weight of offspring, percent of offspring weaned, milk production of dam and interval from parturition to first estrus.

Even though there are considerable data related to the effects of plane of nutrition on reproduction, production and efficiency, many of the results are contradictory. Much of this contradiction can be traced to the following reasons:

1. Due to the temperature extremes in winter and the rainfall extremes in summer, many of the experimental results obtained with livestock apply only to the location in which the experiment was conducted.
2. Experimental treatments have been initiated with animals of different ages, and the duration of treatments has varied greatly.
3. Although almost all experiments with livestock have studied low, medium and high planes of nutrition, the quantitative and qualitative levels of nutrition have not been properly defined.
4. Grazing conditions have varied within and between experiments, and only a few investigators have attempted to measure the energy represented in the forage consumed.
5. In many experiments, body development or skeletal development and body weight gains or condition have not been adequately differentiated.
6. The primary objective of much of the early research was to determine the most economical combination of supplemental energy and protein sources. Therefore, levels of energy and protein which would yield meaningful research results were not utilized in many of the treatment combinations.

The material and methods utilized in the experiments cited in this literature review have been outlined in as much detail as possible in an attempt to help facilitate interpretation of the overall results. In most cases, the experiment will be described the first time that it is cited. Several references are cited in two or more sections; however, they are described in only one section. A special section has also been included in this review to give a brief discussion of factors other than nutrition which may affect the response criteria listed previously.

Effect of Level of Nutrition on Livestock Females

Growth and Body Weight Changes

In a series of winter feeding trials on South Dakota ranges, Johnson, Moxon and Smith (1952) found that the effects of poor and good rations were accumulative if the cows were kept on a given ration over a period of years. When cows were kept on an inadequate ration only one year at a time, the differences in body weight between cows on good rations and poor rations were not extremely large; and these differences were almost eliminated by similar grazing environments during the following summer months.

Joubert (1954) utilized heifers from Jersey, Friesian, Beef Shorthorn and Afrikaner breeds to study the effects of supplemental feed vs. no supplement during winter grazing in the Union of South Africa. Changes in body weights of heifers on the low plane (unsupplemented) showed marked seasonal fluctuations with the peak in weight occurring at the end of the summer. During summer, low plane females derived greater benefits from grazing and showed higher actual and relative gains than cows on the high plane of nutrition. Skeletal development was retarded each winter, and body measurements were considerably lower for the low plane females at the end of the fourth year.

Nelson *et al*. (1954) reported a series of trials in which two systems of management of commercial beef cows were compared: (1) grazed on native grass pastures yearlong and fed 2.57 lb. cottonseed cake per head daily and (2) grazed for 7 months and then fed prairie hay and cottonseed cake during the winter months at the rates of 20.95 and 1.33 lb. per head daily, respectively. These workers reported that the cows fed hay gained 48 lb. during the winter period while the cows receiving only cottonseed cake lost 4 lb. Summer gains were inversely related to winter gains. This inverse relationship was also observed by Zimmerman, 1960; Velasco, 1962; Clanton and Zimmerman, 1970.

Utilizing monozygotic twins of dairy and dual purpose breeds, Hansson (1956) investigated the effects of feeding 60, 80, 100, 120 and 140% of a standard level of nutrition. These levels were fed up to 25 months of age and were then gradually changed to the standard level. Animals on the highest level of nutrition doubled the gains of cattle on the lowest level. The low levels of nutrition did not seem to affect subsequent growth. When heifers on the low level were given additional feed, gains increased up to 500 g per day. The author concluded that within a wide range of nutritional levels, young animals continue to grow; but they do so at different rates, and they reach practically the same final body development at maturity. A similar experiment was conducted by Reid et al. (1957a,b) in which Holstein heifers were fed 65 (low), 100 (medium) and 140% (high) of Morrison's Total Digestible Nutrient (TDN) Standard from birth to time of first calving. During the period between the first and second calving, the quantities of TDN fed to the low, medium and high groups were 118, 109 and 100% of Morrison's standard, respectively. After the second calving, all animals were provided TDN in accordance with Morrison's standard. Average body weights following first calving were 876, 1058 and 1209 lb. for low, medium and high levels, respectively. The low level cows recovered in size and weight by the third calving. Data indicate that dairy cattle have a considerable capacity to grow between 2.5 and 4 years of age if sufficient nutrients are provided. High level cows maintained a weight advantage over the other groups as late as 7 years of age. Reid et al. (1964) reported additional data on the lifetime project. High level cows were heavier than medium level cows (59 lb.) and low level cows (53 lb.) at the end of the fifth calving.

In another experiment with twins, Joubert and Bonsma (1957) fed one twin mate an adequate supply of feed for normal growth and development while the other twin received an inadequate supply. Rations were fed from 8 months of age through pregnancy. Low plane females showed a weight increase from conception until prior to calving of 14.8% compared with a 31.2% increase for the high plane heifers. The low plane dams lost 13.4% of this gain during parturition, and the dams in the high plane group lost 16.8%. Therefore, low plane females increased their body reserves from conception to post-partum stage by 1.4% and the high plane females increased their reserves by 14.4%.

Very few long-term feeding studies with beef females have been reported. Zimmerman (1958) summarized the results of 9 years of research with beef females fed three levels of winter supplement each winter since weaning. Amounts of winter supplement fed per head daily were low, 1 lb. cottonseed cake; medium, 2.5 lb. cottonseed cake; high, 2.5 lb. cottonseed cake plus 3 lb. oats. Cattle grazed native pasture yearlong. The greatest difference in spring body weights occurred when the cows were 5 years old, and high level cows were 138 lb. heavier than low level cows. This difference was reduced to 28 lb. when the cows were 9 years of age. The author stated that the low level cows were more vigorous grazers. Therefore, the actual difference in nutrients consumed by the cows may not have been as great as the difference in amounts of supplement fed would indicate. Pinney (1962) reported additional data from the study just cited. He stated that the heaviest fall body weight attained by the high level females occurred at 7.5 years of age. Both low and medium level females attained their greatest body weight at 10.5 years of age. In the analysis of body measurements, significant differences appeared in body length and height at withers at 3.5 years of age; however, no significant differences were present at 5 years of age. It appeared that body weights after 5 years were measuring condition or fattness and not necessarily size.

Zimmerman (1960) presented data from five long term trials initiated in the falls of 1954-59. Differences in height at the withers were small in all trials; however, there was a consistent trend for height to be directly related to level of winter supplement. Most of the differences in height occurred during the first winter of each trial. When height of the low level females was expressed as a percent of the height of the high level heifers, it ranged from a low of 97.8 at 1 year of age to 98.9 at 1.5 years of age. Low level heifers were 93.6% as long as high level heifers at 1 year of age and 97.1% as long at 1.5 years of age. There appeared to be an anterior to posterior gradient from earlier maturing to later maturing parts of the body. At 3.5 years of age the low level heifers were at least 95.8% as large as the high level heifers in all seven dimensions measured.

Velasco (1962) described three trials in which mature Hereford cows (5 to 10 years old) were fed different levels of supplement on dry range grass from November to mid-April. In Trial I, the treatments were low, no supplement; medium, 2 lb. cottonseed meal; high, 2.4 lb. cottonseed meal plus 3.5 lb. milo. Weight losses from fall to spring including loss at parturition were 34, 22 and 21% fall body weight for low, medium and high groups, respectively. Weight changes in Trial II were similar to those reported for Trial I. In Trial III, cows which had been on the low level were switched to the high level and high level cows were switched to the low plane of nutrition. Winter weight losses were greatest for cows switched to low level; however, they did not gain the most during the subsequent summer. The low level cows which were switched to the high plane did not perform as well as had been expected. The author concluded that cows previously on low levels of nutrition may not respond immediately when placed on high planes of nutrition.

Furr (1959) reported winter weight losses of 25 to 30% of fall weight for fall calving beef cows being wintered on range grass with limited supplement. He concluded that production of mature cows is not greatly affected by weight losses this large; however, production of first-calf heifers may be reduced unless weight loss is reduced considerably. Weight losses reported were from October before calving to spring weighing in April.

Sorenson _et al_. (1959) conducted a very detailed investigation concerning the influence of underfeeding and overfeeding on growth and development of Holstein heifers. Twenty trios were randomized to slaughter ages of 16, 32, 48, 64 and 80 weeks within each treatment. Calves were started on test between 75 and 105 lb. and at 3 to 5 days of age. Treatments were low, medium and high which corresponded to 60, 100 and 140% TDN as recommended by Morrison. Weight gains and body measurements paralleled TDN intake. The average difference in body weight at 80 weeks of age between the low level and the high level heifers was 559 lb. Height at the withers, body length and heart girth measurements were greater for the high level of nutrition.

Another extensive study with dairy heifers was conducted by Crichton, Aitken and Boyne (1959). Treatments utilized were (1) continuous high plane from birth to first calving (high-high), (2) a high plane for the first 44 weeks followed by a low plane until 2 months before calving (high-low), (3) a continuous low plane until 2 months before parturition (low-low), (4) a low plane for the first 44 weeks followed by a high plane to first calving (low-high). From 2 months before first calving until termination of third lactation, all animals were on a high plane of nutrition. The high plane in this experiment was 110% of the Ragsdale recommendation for normal growth. The following body measurements were taken at monthly intervals from 3 months to 6 years of age: height at withers, length of back, heart girth, middle girth, width of hooks and circumference of metacarpus. At 44 months of age, all body measurements of high plane heifers were significantly greater than those of low plane heifers. Body weights of low plane heifers were relatively more affected than any of the linear measurements and averaged only 68% as great as those of the high plane heifers. The high-high group exceeded all other groups in body weight and body measurements except in circumference of metacarpus at 80 weeks of age. Similar results were obtained at 104 weeks of age. The low-high animals overtook the high-low animals in height at withers and circumference of heart and middle girth at about 62 weeks of age. In contrast, animals were 80 weeks old before differences in length disappeared. These authors continued their discussion of the results in another report (Crichton, Aitken and Boyne, 1960a). Within each treatment group, the measurement to reach maturity earliest was circumference of metacarpus, followed by length of back, height at withers and width at hooks. All groups differed significantly from one another in age at which maturity was reached. High-high animals attained maturity 8 to 9 months earlier than the low-low animals in circumference of metacarpus, length of back, height at withers; but in width of hooks, they were only 5 months earlier. In absolute growth rates, significant treatment differences in body weight, heart girth, width of hooks and circumference of metacarpus were still apparent at 182 weeks (3.5 years); however, these differences had disappeared by 260 weeks (5 years).

Swanson (1960) fed one member of twin dairy heifers (4 to 12 months in age) a normal control ration while the other member was fed heavily on concentrates until first calving to produce rapid growth and fattening. After first calving, heifers were fed alike. Fattened heifers weighed 32% more than controls at 24 months of age. They were 0.5 in. higher at withers at 11 months, 1.2 in. higher at 24 months and 1.0 in. higher at 34 months than controls. Two weeks post-partum, the fattened twins had lost an average of 143 lb. compared to a loss of 50 lb. for the control twins. At 9 months post-partum, fattened heifers still lacked 18 lb. in attaining prepartum weight, but controls had gained 142 lb. more.

Experiments with twin beef females have produced information concerning the detrimental effects of rapid gains and excess condition on subsequent lifetime productiveness. Arnett (1963) fed one member of sets of twin beef heifers a high energy ration to achieve maximum possible gain. The second member was fed a ration adequate in all nutrients, but containing a moderate level of energy. During lactation, energy intakes were increased to provide small but consistent gains. All cows were returned to their respective prepartum level before the next parturition. The high level females increased in body weight up to 42 months of age and then maintained a fairly constant weight. The medium level cows increased body weights up to 48 months of age and then leveled off. The high level twins averaged 483, 342 and 273 lb. heavier than moderate level mates at first, second and third parturitions. Levels of feeding influenced body weights much more than body measurements. At 76 months (6.3 years) of age the body measurements of the moderate level cows, expressed as a percent of the high level cows, were as follows: height at withers, 99.3; depth of chest, 94.9; heart girth, 90.8; width of hips, 91.8 and length of head, 101.2. Body weight of the moderate level cows was only 76.8% as great as body weight of the high level cows. In general the weights of the brain, heart, liver, ovaries and pituitary gland from the moderate level cows made up a larger percentage of the live weight although the actual weights were less than those from high level cows. High level cows lost more weight at parturition. They usually exhibited a weight loss during lactation while moderate level cows gained weight. Wiltbank, Bond and Warwick (1965) also reported that heifers on a high level of energy lost more weight at calving than heifers on a low energy level.

Swanson and Hinton (1964) reported on the effects of seriously restricted growth in dairy heifers. One mate from each of nine pairs of identical twin dairy heifers was fed normal feed including hay _ad lib._ and concentrates up to 1 year of age. The other pair mate was fed only roughages from 4 to 24 months of age, and consumption was restricted to 66% of the normal TDN intake. This restriction kept the body weights of the underfed heifers 25% below normal. After the first parturition, all heifers were fed alike. The average first post-partum weights were 652 lb. for normal and 509 lb. for subnormal heifers (78% of normal). The third pre-partum weight showed subnormal cows averaged 97% of the weight of normal cows. A difference of 1.9 in. in wither height before first calving was reduced to 1.0 in. by the start of the third lactation.

Wiltbank, Bond and Warwick (1965) investigated the effects of different levels of energy and protein intake on the reproductive performance of beef females through the second calving. A 3 x 3 factorial arrangement of treatments with 3 levels of energy and 3 levels of digestible protein (DP) was utilized. Energy levels were high, ad lib.; medium, 66% of high; low, animals fed just enough to maintain body weight. Protein levels were high, 0.23 lb. DP per hundredweight (cwt.); medium, 0.15 lb. per cwt.; low, 0.06 lb. per cwt. Heifers were kept on their respective rations until 180 days after the first calf or until 90 days pregnant with the second calf, whichever occurred first. All heifers were then placed on a common hay-cottonseed meal ration. Body size was not affected permanently by the rations fed. Prior to first breeding, body weights ranged from 730 lb. for heifers on high energy-high protein ration to 394 lb. for heifers on low energy-low protein ration. Body length measurements differed as much as 11 cm, and difference in height at withers was 8 cm. These differences disappeared after heifers were placed on the hay ration.

Bernard and Lalande (1967) investigated simultaneously the effects of age at first calving and winter plane of nutrition on live weights of beef cows. Heifers were subjected to low and high planes of nutrition during the wintering period. One-half of the heifers were bred to calve as two-year-olds and half to calve as three-year-olds. At the end of the wintering period when heifers were 24 months old, those bred at 15 months and raising calves weighed 54 kg less than those kept open. When calves were weaned at the end of the grazing season, the difference due to calving was 88 kg. Subsequently, the cows calving at 24 months increased in weight more rapidly than those calving at 36 months. At 3.5 years of age, the average difference was 54 kg, and this decreased to 40 and 28 kg at 4.5 and 5.5 years of age, respectively.

The high level heifers, receiving 22% more TDN than low level heifers, increased body weight by 57 kg over the low level heifers. This difference in body weight decreased rapidly with time; and at 3.5 years of age, there were no significant differences. The wintering ration had an immediate effect on the weights of cows, but the effect soon disappeared so that animals wintered on the low plane attained the same weight as those wintered on the high plane.

Additional work has been reported on the effect of nutrition in very early life on the growth and performance of beef females. Totusek (1968) subjected Angus and Hereford heifer calves to low, medium and high planes of nutrition previous to weaning by weaning at 140 days, weaning at 240 days, and creep feeding and weaning at 240 days. Compared to normal weaning, early weaning resulted in a slight decrease in weight to 4 years of age; however, there was no permanent effect on appearance and skeletal size. Differences in wither height between early-weaned and creep-fed heifers approached 2 in. at 240 days of age, but these differences disappeared by 2 years of age.

Kothmann, Mathis and Marion (1968) reported on the effects of various combinations of winter protein supplementation and pasture stocking rates on range beef cows. A factorial arrangement of treatments was used with two main effects -- supplement at three levels and stocking rate at two levels. All cows used in the experiment were 3 years of age. Levels of protein were 0, 1.5 and 3.0 lb of 41% cottonseed cake, and levels of stocking were 20 acres per cow and 13 acres per cow. Cows receiving supplement weighed proportionally more than those not receiving supplement. Cows on all levels of supplement weighed the least in the spring and the most in early or mid-summer. A highly significant interaction between level of supplement and stocking rate was observed. At 20 acres per animal unit, average cow weights increased with supplementation. However, at the heavier stocking rate, cow weights showed no significant change as a result of supplementation. Apparently, energy was the limiting factor in this case.

In an experiment similar to the one described previously by Wiltbank <u>et al</u>. (1965), Bond and Wiltbank (1970) reported that during the first lactation, body weights were higher for beef heifers receiving high and medium levels of energy or protein than for heifers receiving low energy or low protein. During the second lactation, all females lost weight with heifers which had previously received high energy or high protein diets losing more weight than other heifers (-90 kg and -70 kg, respectively). Heifers previously fed low energy and low protein lost the least weight (-18 kg and -12.5 kg, respectively).

Swanson (1967) presented a profile for optimum growth patterns for daily cattle with the following key statements:

1. Maintain a moderately slow growth rate for heifer calves

resulting in just enough body size and development to allow breeding at 14 months.

2. Continue the slow growth rate possibly on roughage feed only until 9 to 12 weeks prepartum.
3. Gradually increase the level of feeding by adding concentrates so that the heifer is gaining weight rapidly before calving.
4. Continue feeding the heifer liberally through the first lactation to allow for growth as well as lactation.

In summary, it appears that beef females have the ability to compensate for growth restrictions when adequate nutrition is provided. Differences in body measurements brought about by differences in nutrition will tend to diminish when animals are placed in a common environment conducive to growth. The intensity of rearing, thus, primarily influences the rate of growth. The majority of the research data indicates that the most critical period of the beef female is during early life to include first pregnancy and lactation periods. Most researchers have observed that cows in excess condition will lose more weight at parturition than thin cows, and summer weight gains are usually inversely related to winter gains.

Reproduction

The level of nutrition of the female has been shown to affect the age and size at puberty and the interval from parturition to first postpartum estrus.

Swanson and Spann (1954) observed that Jersey heifers fed for rapid growth and fattening were heavier at breeding age (15 months) than heifers fed for normal growth; however, they were similar in skeletal size (628 vs. 548 lb., 61.0 vs. 57.4 in. heart girth and 43.0 vs. 42.7 in. height at withers). Sorenson et al. (1959) used three levels of energy based on Morrison's standard (high, 140%; medium, 100%; low, 60%) to study the effects of nutrition on the growth and sexual development of young Holstein heifers. Calves on the high level had an average age of 37.4 weeks at first estrus as compared to 47.1 weeks for the medium level group and 72 weeks for the low level group. Body weights were high level, 580 lb.; medium level, 597 lb.; and low level, 502 lb. High level heifers had reached a greater height by the time of first estrus, but they were shorter in body length than the other two groups. Joubert (1954) recorded a delay in puberty of 221 days when heifers on a low plane of winter nutrition were compared with heifers on a high plane. Although the age at first heat was markedly affected by treatment (low, 20.5 months; medium, 11.2 months; high, 9.3 months), all heifers experienced heat at about the same skeletal size (Reid et al., 1957a). Crichton et al. (1959) reported similar results.

Clanton, Zimmerman and Albin (1964) fed Hereford heifer calves rations varying in energy and protein content in order to determine treatment effect on pubertal age. The average ages at puberty were high protein-high energy, 384 days; high protein-low energy, 469 days; low protein-high energy, 459 days; low protein-low energy, 471 days. Ninety-three percent of the heifers fed the high protein-high energy ration cycled by 15 months of age as compared to 36% of those fed the other rations. Reid et al. (1964) reported that the age of onset of puberty in Holstein heifers was inversely related to the level of energy consumed from birth. The low level of energy deferred puberty by 39.4 and 48.1 weeks, respectively, when compared to moderate and high levels of energy intake. Puberty occurred at about the same body weight and size.

Turman, Pope and Stephens (1965) observed that range beef heifers wintered on a high plane of nutrition calved 2.5 weeks earlier with their first calf and 5 weeks earlier with their second calf than did the low level heifers. At the second calving, approximately one-half of the difference was due to later breeding as yearlings as evidenced by later calving at 2 years of age for the low groups. The remainder of the delay in date of calving with the second calf was due to the longer post-partum interval from calving to conception. These intervals were: high, 74 days; moderate, 86 days; low, 95 days. Christenson _et al_. (1967) reported similar results when yearling Hereford heifers were fed high and low levels of energy during a 140-day pre-calving period. In beef females wintered on range grass and fed low, medium, high or very high levels of supplementation, Zimmerman (1960) observed that the differences in average calving dates between low and high lots were 17, 23 and 10 days for first, second and third calf crops. Apparently, the low level of supplementation delayed estrus and/or required more services per conception.

Most workers have reported that age at puberty is inversely related to energy consumption. Age varies considerably; however, body weight and size are usually similar, regardless of the plane of nutrition. Low levels of nutrition appear to delay occurrence of post-partum estrus.

Performance of Offspring

The indirect effects of level of nutrition of the dam can be measured in performance of the offspring as indicated by birth weight, average daily gain and weaning weight. Coop (1950) reported on a series of trials in which the plane of nutrition for sheep was varied at stages in pregnancy and lactation. A live-weight gain of 25 to 40 lb. from breeding to lambing was adopted as a standard for the high plane and a gain of ±5 lb. was set for the low plane. The high plane of nutrition during pregnancy increased birth weights by 0.5 lb., but had little influence on rate of growth and weaning weight of lambs irrespective of the subsequent level of nutrition of the dam. The level of nutrition after lambing was most important and accounted for almost all of the difference in weaning weights of the lambs. Joubert (1954) found that heifers on a low plane of winter nutrition produced calves weighing 7.5 lb. less at birth than calves from high plane heifers. The weaning weights of calves of beef breeds were significantly reduced by the low plane of winter nutrition for the dam. With Holstein heifers, Reid <u>et</u> <u>al</u>. (1957a) found that although the weight of calves dropped by heifers fed a low plane of nutrition was significantly less than that of calves born to medium and high groups, the weight of the calves was greater relative to the size of the dam. As a percent of dam's weight, the weight of the calves dropped at first calving were: low, 9.7; medium, 8.3; high, 7.8. Joubert and Bonsma (1957) observed that heifers which increased their body reserves by 14.4% from conception to post-partum stage had calves only 4.3% (nonsignificant) heavier at birth than calves from heifers which increased body weight by 1.4%. Since low plane heifers lost less weight at parturition, they concluded that the fetus is maintained not only at the expense of the dam, but also at the expense of the placenta and accessary fluids and tissues of reproduction. In the long-term experiment initiated in 1948 and reported by

Zimmerman (1958), the level of winter supplementation (cottonseed cake or cottonseed cake plus oats) had no significant effect on birth weights and weaning weights. Average birth weights corrected for sex were 76.9, 77.1, and 78.3 lb. for low, medium and high planes of nutrition while weaning weights were 487, 473 and 485 lb.

Furr (1959) found that the high level of winter supplement (cottonseed meal plus grain) increased weaning weights by 30 lb. and 27 lb. for calves from fall-calving cows and heifers, respectively. Zimmerman (1960) reported that spring-calving heifers fed a low level of winter nutrition produced significantly lighter calves in the first three calf crops. The greatest reduction in birth weight of low level calves was in those trials and years when heifers were losing weight most rapidly during the latter part of the gestation period. The low level of winter supplementation also resulted in significantly lighter calves at 210 days in the first three calf crops. The differences in 210-day calf weights between medium and high levels of winter nutrition of the dam were small, but consistently in favor of the high level of supplementation. Johnson _et al_. (1952) observed that cows which maintained their body weights best during winter produced more calves and weaned heavier calves.

Velasco (1962), using mature (5- to 10-year-old) cows, reported that low level cows produced calves 10 lb. lighter at birth than medium and high level cows. Weaning weights were 423, 480 and 527 lb. for low, medium and high levels of wintering, respectively. In a second trial wherein low level cows were supplemented with 1 lb. cottonseed meal from calving to mid-April, there were no significant differences in birth weight; however, cows on the low level weaned calves significantly lighter than calves from the medium and high level groups.

In an experiment in which ewes were fed high and low planes of nutrition from weaning to 16 months of age (Bradford, Weir and Torell, 1961), there was little difference in mean lamb weight between the two treatments over the first 5 years of the experiment; however, the average total weight of lamb weaned per ewe favored the low plane.

Pinney (1962) observed that beef cows on a high level of winter supplementation (protein plus energy) gave birth to the largest calves in eight out of 12 calf crops. When weaning weights were corrected for sex and age at weaning the calves from the low plane group had a six pound advantage over the medium and high plane groups. This weight advantage was lost when weights were not corrected for age since the low plane cows calved later in the year. Hight (1966) reported that a low level of nutrition during the gestation period of Angus cows resulted in lighter calves at birth (12 lb.) and at weaning (36.4 lb.) when compared to calves from cows on a high plane of nutrition. Wiltbank _et_ _al_. (1962) reported similar results in regard to birth weight.

Neville (1962) imposed three different nutritional treatments on pregnant beef cows approximately 2 months before parturition. Rations were grass silage plus 1 lb. of cottonseed meal, corn silage plus 1 lb. cottonseed meal and corn silage plus 1 lb. cottonseed meal plus limited winter pasture. Cows remained on respective treatment until calves were 4 months old at which time all groups were placed on permanent summer pasture. Treatments had significant effects on calf traits. When compared to calves from cows fed only corn silage and cottonseed meal, calves from cows receiving winter pasture in addition to corn silage and cottonseed meal had weight advantages of 72 lb. and 66 lb. at 4 months and 8 months, respectively. Harris, Anthony and Brown (1962) also reported an improvement in adjusted weaning weights of calves from cows fed a high plane of nutrition during the winter. Arnett (1963) found that moderately-fed beef heifers produced slightly heavier calves at birth and had heavier calves at weaning than did heifers on full feed.

Renbarger _et al_. (1964) observed that birth weights were significantly decreased when beef heifers were fed a low plane (25% loss of fall body weight) of nutrition from November 1 to spring calving when compared to the high level (less than 7% loss of fall body weight). Low plane of nutrition from the prepartum period through weaning resulted in lower calf average daily gains than did high levels fed for the same period (1.36 vs. 1.62 lb.).

In a series of trials with mature Hereford cows, Wallace and Raleigh (1964) obtained conflicting results. When cows were wintered on 100% and 60% NRC recommended energy levels, no significant differences in birth weights or weaning weights occurred. In the second trial, cows fed a high energy-low protein diet produced calves significantly lighter at birth than those from cows fed balanced energy and protein or low energy-high protein. No significant differences were observed in weaning weights. Bond _et al_. (1964) utilized a 3 x 3 factorial arrangement of treatments with three levels of energy and three levels of protein for beef heifers. Rations were fed until 180 days after first calving. At this time all heifers were placed on a high roughage ration _ad lib_. Birth weights of first calves were significantly lower in groups receiving low energy rations. Protein had no significant effect on birth weights. Neither protein nor energy level affected birth weights of second calves. Hobbs, Wilson and Odom (1965) determined the effects of first winter ration on the subsequent performance of Angus heifers. Treatments were corn silage *ad lib*. plus 4 lb. of alfalfa hay daily vs. corn silage *ad lib*. plus 4 lb. alfalfa hay plus 6 lb. corn, cob and shuck meal. No significant treatment effects were observed in the first calf crop.

Dunn *et al*. (1965) reported on the effects of two pre-calving and two post-calving digestible energy (DE) levels for two-year-old Hereford and Angus heifers. Pre-calving levels were 7.7 megcal (low) and 17.4 megcal (high) per day. At calving the low group was divided into two groups: low-moderate which was fed 27.4 megcal and low-high which was fed 48.4 megcal per day. The high pre-calving group was divided into three groups: high-low group which received 14.1 megcal, a high-moderate group which was fed 27.4 megcal and a high-high group which received 48.8 megcal per day. All calves were creep fed *ad lib*. Calves reared by dams fed the high pre-calving energy gained 7 kg more from birth to 109 days of age than calves reared by dams fed the low pre-calving level. By 120 days, calves from dams fed the high pre-calving energy level weighed 9 kg more than calves from low energy dams. Calves from dams in the high-low group weighed 10 kg less than the mean weight of calves from the other four groups at 120 days. Melton, Cartwright and Nelson (1967b) reported that calf gain was very highly correlated with feed intake of the cow. Marion and Hammack (1969) observed that winter energy levels ranging from 11.8 to 20.7 therms for cows in drylot and 1.6 to 7.1 therms for cows on pasture had no significant effects on calf weaning weight.

It appears that both energy and protein intake by the dam will affect the birth weight of the calf. Most data indicate that energy level has a greater influence than protein level. Low levels of energy result in lower actual birth weights, but calves are heavier in relation to dam's body weight than calves from dams fed high levels. Cows that gain the most or lose the least during winter tend to produce faster gaining calves while the converse holds true with regard to summer gains. Apparently, the influence of the energy intake of the dam on calf gains is expressed in milk production. Therefore, the effects of feed intake of the dam on total milk production must be analyzed before conclusive statements concerning the relationship of dam's nutrition and calf gain can be made. This is further evident since it has been shown that energy intake of the female to the point of excessive fattening in early life can be detrimental to milk production.

Milk Production of the Dam

Investigators in both the dairy and the beef fields recognize the fact that energy and protein intake will affect total milk production; however, the optimum levels of nutrition for maximum production are difficult to define. This is particularly true with beef females. Data indicate that energy intake above a certain level and at particular stages in life can be detrimental to milk production.

Flux (1950) stated that "although it might appear that animals which have been underfed prior to their first lactation produce less milk than those which were better fed because they use more of their nutrient intake for growth, the greater growth may be due, in part, to a smaller demand for milk precursors from a less well-developed mammary gland." He found that dairy heifers placed on a high plane of nutrition (1 lb. gain per day) 10 weeks before calving produced more milk during the lactation period (4244 lb. vs. 3187 lb.) than heifers fed to maintain body weight.

Thomson and Thomson (1953) concluded that udder development and capacity for lactation are governed by the nutrition of the ewe in the latter stages of pregnancy. Joubert (1954) found no significant differences in milk production due to supplementing dairy heifers on winter pasture; however, the low plane heifers started at a lower level of production, but were more persistent.

After extensive studies with ewes, Barnicoat _et al_. (1956) reached the following conclusions:

1. Milk production of the ewe is the major factor influencing the rate of live-weight gain of the lamb.
2. Weight of the milk or total quantity, rather than its composition, gives the best index of its lamb-fattening qualities.
3. The factor most capable of influencing the quantity of milk produced is the plane of nutrition of the ewe. Adequate feeding during lactation maintains milk production in the early lactation while liberal feeding during pregnancy helps to sustain milk flow, particularly in the later stages of lactation.

Swanson and Spann (1954) observed that Jersey heifers fed at a normal rate produced almost twice as much milk as twin mates which had been fed for rapid growth and fattening. They concluded that excess fattening during growth is detrimental to lactating ability. Swanson (1957) reported that udder sections from the fat heifers showed that development of the lobule-alveolar system had been inhibited by fat deposits. Hansson (1956) also showed that very high levels of nutrition during growth could be detrimental to milk production. He compared identical twins fed at 40, 60, 80, 100 and 120% of a standard energy intake from 1 to 25 months of age and found that the 80% level heifers produced the highest average milk yield. When identical twins fed at standard rates were compared with those fed at 140% standard, the fattened heifers milked only 85% as much as the controls.

Additional adverse effects of an extremely low or high plane of nutrition were revealed by Sorenson et al. (1959). They reported that at 16 weeks of age, the glandular tissue comprised 31% of the udder weight of dairy heifers on a low plane of nutrition while this value was 63 and 9% for heifers on medium and high planes of nutrition, respectively. The mammary glands of the heifers on the high level of feeding were rather consistently infiltrated with fat cells. Swanson (1967) summarized work at the Tennessee Station and concluded that both overfeeding and underfeeding prevent expression of normal lactation potential. The subnormally reared twins recovered to normal milk yields in the second lactation, but some of the fattened twins were still below normal in the second lactation. This tends to indicate that the adverse effect of a high level of nutrition (probably due to fat deposits in the udder) may be irreversible.

When Holland (1961) compared the milk production of beef heifers fed moderate and high levels of energy during the growing phase, he found that the moderate heifers produced more milk than the fat heifers (112-day average, 9.2 lb. moderate, 6.8 lb. high; 210-day average, 8.8 lb. moderate, 5.0 lb. high). The correlation between milk production and calf gain on a within-twin basis was 0.75. When he fed a high plane of nutrition to mature beef cows during gestation and then placed them with moderately fed mature cows upon calving, the calves from the high level cows were heavier at weaning. This was in contrast to the results with the heifers. It appears that the mature cow is not as easily injured by excessive fat as the developing heifer. Arnett (1963) reported that milk yields from moderately fed heifers were consistently, but not significantly, higher than twin mates fed at very high levels of nutrition.

When dairy heifers were fed at low, medium and high level of nutrition from birth to time of first calving, subsequent milk yield through the fifth lactation was not significantly affected; however, the low level cows produced slightly more fat-corrected milk than medium and high level females through the fourth lactation (Reid et al., 1957a).

After dairy heifers were fed high and low planes of nutrition from birth to 44 weeks and then switched from one treatment to the other (Crichton, Aitken and Boyne, 1960b), fat-corrected milk yield adjusted to average lactation length was significantly lower for the high-low heifers in the first two lactations as compared to the high-high, low-high and low-low groups. The authors pointed out that the high-low heifers were larger than the low-low heifers at the time of the ration change; therefore, their maintenance requirement was greater. This may have accounted for a portion of the reduced production of the high-low group during lactation.

Swanson et al. (1967) concluded that a slow growth rate will not affect first lactation yield if pre-partum supplemental feeding to improve body condition is practiced. Twin dairy heifers were fed so that one twin had normal growth while the mate was limited to 69.5% of the controls up to 91 weeks. In the 12-week pre-partum period, concentrates were fed to the slow growth heifers, but not to the controls. The slow growth heifers were therefore approaching the controls in body weight at calving. During the first lactation, milk yields of the slow growth heifers averaged slightly, but not significantly, higher than those of the controls.

Most workers have reported significant correlations between milk production and calf gain, especially during the early phase of the lactation period. Gifford (1953) reported correlations between daily milk production by beef cows and daily gain of their calves of 0.60, 0.71, 0.52 and 0.35 for the first, second, third and fourth months of lactation, respectively. Howes et al. (1958) allotted Hereford and Brahman heifers to two treatment groups which received 100% and 50% of the NRC recommended protein allowance. Protein level of the ration significantly affected calf growth and milk yield. These two criteria were significantly correlated through the first 4 months of lactation (0.67, 0.83, 0.50, 0.45). The calculated dry matter and protein supply became inadequate to maintain the calf growth obtained between the second and third month in all experimental groups indicating that from the third month, the calves must have received much of their nutrient supply from grass.

Velasco (1962) found that mature Hereford cows wintered on a low plane of nutrition (no supplement during winter with 1 lb. cottonseed meal from calving to mid-April) produced less milk than cows on a high level (6.25 vs. 8.12 lb.). High level cows weaned calves 56 lb. heavier than calves from low plane cows. In general, calf gains were highly correlated with milk production during the first 3 to 4 months of lactation. Correlations for the entire lactation were 0.76 for the low level and 0.55 for the high level.

Brumby, Walker and Gallagher (1963) found the correlation between weaning weight at 6 to 7 months of age and dam's milk supply to be 0.70. Melton et al. (1966) found significant correlations between total calf gain and yield of butterfat (BF), solids-not-fat (SNF), total solids (TS) and total milk of 0.38, 0.61, 0.58 and 0.58, respectively. Melton et al. (1967b) reported that energy intake of the cow was rather highly positively correlated with milk yield and calf gain. Calf gain was highly and positively correlated with milk yield. These same workers (Melton et al., 1967a) found a correlation of 0.40 between total calf gain and milk production in beef cattle.

Wistrand and Riggs (1968) found that the amount of milk per pound of calf gain averaged 6.60 and 7.41 lb. for two consecutive years. The correlation of estimated milk production with corresponding 205-day adjusted calf weaning weight was 0.60. At 120 days, the correlation was also 0.60.

Riggs (1969) summarized work at the Texas Station and stated that calf growth rate and weaning weight increase significantly in a stepwise manner as the daily allowance of standard milk (4% BF) is increased from 5 to 7 to 10 percent of calf body weight. The quantity of milk solids seems to be more important than BF. Total pounds of milk, BF, SNF and TS showed significant correlations with weaning weight of 0.83, 0.77, 0.85 and 0.85, respectively. Klett, Mason and Riggs (1965) observed that in data from combined Angus and Hereford herds, cows producing in the ranges of 2.50, 3.41 and 4.55 kg milk per day weaned calves weighing 166, 183 and 205 kg at 205 days of age.

Harris et al. (1962) reported that cows wintered at a high level weaned calves that were 43 lb. heavier than calves from cows wintered at a restricted level. Daily fat corrected milk (FCM) for the two groups on April 1 was 9.18 and 6.02 lb. for high and restricted groups, respectively. After 56 days on lush spring grass, milk production values were almost equal. Data indicated that beef cows on restricted winter feed declined in milk production during the period of restricted feeding, but showed a response to lush grazing. For the period 3 to 30 weeks after calving, the difference in yield remained significant, but the average differences in SNF and fat content over this period were not significantly different.

When Hereford heifers were wintered at low and high levels of nutrition and one-half of each group was switched at calving, Renbarger et al. (1964) found the daily milk yields to be 8.2, 9.4, 9.7 and 10.7 lb. for low-low, low-high, high-low and high-high groups, respectively. Corresponding average daily gains of calves were 1.36, 1.47, 1.54 and 1.62 lb.

In the lifetime experiment reported by Reid et al. (1964), the levels of nutrition imposed from birth to first calving did not have a significant effect on total milk production or FCM in any of the lactation periods. In all lactations, cows which had received the low plane produced milk with a lower fat percent.

Broster, Tuck and Balch (1964), utilizing Friesian heifers and rations varying in protein and energy content, found that animals fed to gain 0.5 lb. per day during the last 5 weeks of pregnancy gave as much milk as heifers which gained 2.0 lb. per day. Gardner and Hogue (1964) reported that when ewes were fed 113% of NRC recommended DE level during the first 90 days of lactation, the total milk yield, milk caloric production and lamb weights were significantly increased as compared to a DE level of 96%. Levels of DE had no significant effect on other milk composition criteria.

Work by Dunn et al. (1965) revealed that both pre- and post-calving levels of feeding affected milk production of Angus and Hereford heifers. Estimates of milk production were taken when calves averaged 53, 81 and 109 days of age. Cows fed the low pre-calving energy level produced less milk at all stages of lactation than did cows fed the high pre-calving level; however, this was statistically significant only at 81 days post-calving. Cows fed high post-calving levels produced more milk at all stages of lactation than did moderate levels after calving (increase of 2.0 kg at 53 days, 1.2 kg at 81 days and 1.3 kg at 109 days). The high-low group produced less milk than the average of the other four groups at all stages.

Christenson et al. (1967) found that Hereford heifers which had been fed high and low 140-day pre-calving energy levels produced calves which had the following weights at 2, 4, 6 and 8 weeks of age: 36.2, 31.8 kg; 46.5, 40.6 kg; 54.3, 47.7 kg; 64.7, 51.1 kg, respectively.

Gillooly et al. (1967) found that level of energy intake of Angus x Holstein cows during lactation affected total milk yield. Percent SNF, total kcal and solids-corrected milk. Percent BF, kcal per kg and percent protein were not significantly affected by energy levels.

Bond and Wiltbank (1970) reported that both energy and protein levels fed to heifers from weaning to 180 days post-calving affected milk production. In the first lactation, milk production was significantly lower in the females receiving the low levels of energy or protein than in high or medium levels. The high and medium level protein heifers peaked in lactation at 60 to 90 days. Milk yield for high energy females peaked at 90 to 120 days while medium level heifers peaked at 60 days. During the second lactation, heifers fed the low protein diets continued to have a lower milk yield than heifers which had received the higher levels of protein. The females which had received the low energy diet had the highest milk yield when considering all of the females which had received the different levels of energy. Calves from heifers on the high and medium protein diets gained faster than the low level calves; however, the low level calves converted milk to body weight more efficiently. Calves from heifers in the high and medium energy groups gained faster than the calves from low level dams; yet these slow gainers were more efficient in conversion of milk to gain.

The level of nutrition of the dam in early life may affect subsequent lactating ability. Females which have been fed for rapid gain and fattening usually have a lower milk yield than heifers fed for normal growth. Limited data indicate that this may be due to fat deposits in the udder. Both pre- and post-calving levels of energy and protein for the dam will affect milk yield and composition; however, they seem to affect total milk yield to a greater degree than milk components. Calf gains usually parallel milk production of the dam. Correlations between these two traits are higher during the early stages of lactation when the calf is more dependent upon milk as a nutrient source.

Effects of Other Factors on Response Criteria

Age of Dam

In herds of Hereford cows where all cows were culled when they reached 11 years of age, Knapp, Baker and Quensenberry (1942) found that calves from two-year-old cows were usually small, while the largest calves came from four-year-old cows. These authors reported that weaning weights of calves increased with age of cows through 6 years and then decreased with age up to 11 years. Knox and Koger (1945) obtained maximum calf production with seven-year-old range beef cows. Burgess, Landblom and Stonaker (1954) observed that weaning weights of Hereford calves increased with increasing age of dam through 8 years. Rollins and Guilbert (1954) reported a similar optimum age. Several other workers have reported that maximum calf weaning weights were obtained with cows in the range of 6 to 10 years of age (Marlowe and Gaines, 1958; Pahnish _et al_., 1961; Godley, Wise and Godbey, 1966). When Castro, Riggs and Talcott (1969) studied factors affecting weaning weight of Santa Gertrudis range-raised calves, they found the age of dam effect to be linear in one herd and curvilinear in another herd. They concluded that the type of management must be considered in corrections for weaning weights.

Marlowe, Mast and Sheehan (1964) observed that calf gains from birth to weaning increased with cow's age from 2 to 6 years, remained approximately the same for 6 to 11 years and decreased slightly thereafter. Godley _et al_. (1966) observed that calves from three-, four- or five-year-old cows gained less from birth to weaning than calves from older cows (6 to 12 years of age). Birth weights of calves from three-year-old heifers (calving for the first time) were lighter than at other ages. Jamison (1967) reported that a beef cow's performance as measured by gain of calf from birth to weaning was lowest at 2, 3, 4 and 11 years of age. Fitzhugh, Cartwright and Temple (1967), using 5,117 dam-calf pairs from 10 state experiment station herds, observed that the age of dam effect on daily gain of the calf was apparently curvilinear. They reported that calf average daily gain increased with dam's age up to 7 to 9 years and then decreased.

Marlowe (1962), in an extensive study with Angus and Hereford cattle, reported that there was an increase in calf birth weight of 1 2/3 lb. for each year increase in age of dam up to 7 years. Koonce and Dillard (1967) also observed a significant age of dam effect on birth weight. Dams 3 and 4 years of age gave birth to calves weighing 2.64 and 0.95 kg, respectively, less than the least squares mean birth weight while eight-, nine-, ten- and eleven-year-old cows gave birth to calves weighing 0.63, 1.03, 0.82 and 1.12 kg, respectively, more than the least squares mean. Least squares constants for dams 5, 6, 7 and 12 or more years of age did not differ significantly from zero. Koger et al. (1962) found in their study with Brahman, Shorthorn and various crossbred groups that calving rates were lowest in the two- and three-year-old cows and highest with six- and seven-year old cows.

The age of dam also has a pronounced effect on milk production. Gifford (1953) found that milk production of beef females increased up to 6 years of age. Clark and Touchberry (1962) analyzed records of Holstein cows for lactations one through eight and found that when body weight was held constant, each increase of 1 month of age was accompanied by an increase of 46 lb. of milk and 12 lb. of fat in the first lactation. When all lactations were combined, each month increase in age was accompanied by an increase of 28.4 lb. of milk and 0.9 lb. fat. Bereskin and Touchberry (1966) reported that age at freshening, when included with days the calf was carried as the only additional covariate, was significantly associated with first lactation yields of milk fat and FCM for dairy females. However, when age at freshening and body weight taken soon after calving were both included as covariates, weight retained its importance; but the independent association of milk yield with age became trivial.

The effect of age of dam on persistency of milk production is not clearly defined in beef cattle. Todd, Fitzhugh and Riggs (1969) observed that younger beef cows showed a sharp decline in milk yield from the middle of the lactation period to the latter portion of lactation while cows 6 years and older showed little decline. Christian, Hauser and Chapman (1965) reported that three- and four-year-old cows produced more milk than two-year-olds; however, two-year-old cows were more persistent and yielded 4.7% more of their total milk during the period 60 to 240 days post-partum than the older group. Rollins and Guilbert (1954) found that calves from first-calf heifers and from second-calf heifers grew faster from 4 to 8 months of age than calves from optimum production age. They contributed this to greater persistency in lactation.

Riggs (1969) summarized data which indicated that milk production increased as age of dam increased from 2 years to 6 to 8 years. He concluded that much of the breed and age of dam effects on weaning weight can be attributed to differences in milk production.

Most workers have reported that calf birth weight increases through the third or fourth calf crop. Age of dam has also been shown to affect milk production, calf average daily gain from birth to weaning and calf weaning weight. The exact age for maximum production apparently is in the age range of 6 to 10 years. It appears that the increased calf weaning weight associated with older cows is due to an increased milk flow.

Sex of Calf

Sex of calf has been shown to have an effect on birth weight, average daily gain and weaning weight. Data also indicate that sex of calf may influence dam's milk flow through an increased nursing stimulus.

Knapp _et al_. (1942) obtained a significant sex difference of 5.79 lb. in birth weight and 22 lb. in weaning weight in favor of male calves in the Hereford breed. Koger and Knox (1945); Koch and Clark (1955); Clum, Kidder and Koger (1956) and Godley _et al_. (1966) reported similar results. Pahnish _et al_. (1961) reported a male advantage in weaning weight of 44 to 99 lb., while Brown (1961) found a range of 22 to 57 lb. Gregory, Blunn and Baker (1950) observed a birth weight advantage for bull calves ranging from 4 to 5 lb. with no significant differences between males and females in average daily gain and weaning weight. The effects of sex of calf on weaning weights of Hereford calves measured in lb. as deviations from the average weaning weight were steer, -6; bull, 14; and heifer, -8 (Burgess _et al_., 1954).

Rollins and Guilbert (1954) reported that bull calves gained 0.13 lb. per day more than heifer calves from birth to 4 months of age, and at 8 months male calves outweighed females by 68 lb. Marlowe and Gaines (1958) utilizing data from Hereford, Angus and Shorthorn herds, observed that bull and steer calves grew 8 percent faster than heifer calves. When weaning weights were adjusted to 210 days, bulls were 16 lb. heavier than steers and steers were 30 lb. heavier than heifers. In another study where bull calves were not castrated, Koch _et al_. (1959) reported that bull calves averaged 5.2 lb. more than heifers at birth and that they gained 0.113 lb. more per day or 1.073 times faster than heifers. Marlowe, Mast and Schalles (1965) stated that the growth rates of bulls over steers and steers over heifers from birth to weaning were 7 and 6 percent, respectively.

Jamison (1967) observed that male calves had an average daily gain from birth to weaning 0.16 lb. greater than females. Fitzhugh *et al*. (1967) reported that the sex effects on average daily gain as pooled deviations from herd means were bull, 0.13; steer, -.05; and heifer, -.08 lb.

With data from Angus, Hereford and Charolais cows, Melton *et al*. (1967b) found that cows nursing bull calves produced more milk (0.58 kg) per day than cows nursing heifer calves in the first period of lactation. The sex difference diminished progressively during lactation to 0.10 kg per day during the last period. Todd *et al*. (1967) reported that cows nursing steers produced 0.56, 0.60 and 0.18 lb. more milk than those nursing heifers at three milkings during the lactation period. The average of all three milkings was 0.44 lb. which was statistically non-significant; however, steer calves gained 28 lb. more than heifer calves.

Research results reveal that bull calves will weigh 4 to 5 lb. heavier at birth than heifer calves. Male calves will gain at a faster rate from birth to weaning and, therefore, will weigh more than females at weaning age. Limited data indicate that cows nursing male calves will produce more milk during lactation than cows nursing heifer calves.

Age of Calf

Burgess *et al*. (1954) stated that age of calf at weaning had a significant effect on weaning weight. They found that for each day increase in calf's age, the weaning weight increased by 1.67 lb. Minyard and Dinkel (1965) also reported a significant age of calf effect at weaning on weaning weight. Linear regression of weight on age was 1.20 lb. Castro *et al*. (1969) found age of calf to be the greatest source of variation in weaning weights in two herds of Santa Gertrudis cattle. The regression coefficients of weight on age of calf were 0.58 and 1.81 lb. for the two herds.

Marlowe and Gaines (1958) investigated the effects of age of calf on pre-weaning growth rate and type score of Virginia beef calves. They found no significant differences in growth rate of non-creep-fed calves from 90 to 210 days. However, there was a slight decline in the next 30-day period and a sharp decline from 241 to 300 days. They contributed the sharp decline to the end of lactation and poor grazing conditions.

Drewry, Brown and Honea (1959) obtained correlation values between age of calf and calf weight at milk samplings of 0.58, 0.28 and 0.16 for the first, third and sixth months of lactation, respectively. Correlations between age of calf and total gain from birth were 0.86, 0.50 and 0.30. The values indicate that during the first month, the older calves were heavier, but as lactation progressed, the calves born earlier tended to lose some of the weight advantage.

In a report by Swiger (1961), the average daily gain from birth to weaning was 1.61 lb. for bulls and 1.46 lb. for heifers, while the regressions of weight on age computed from a least squares analysis were 2.0 lb. for bulls and 1.4 lb. for heifers. The difference indicates that bulls grew at a much faster rate immediately prior to weaning than they did earlier. In studying the influence of age of calf on gain, Marlowe (1962) found a decrease in average daily gain with an increase in calf age from 60 days to 300 days among non-creep-fed calves. In extreme cases, this reduction was 0.1 lb. per day. Swiger et al. (1962) conducted a partial regression analysis of gain from birth to 130 days and 130 days to 200 days on calf age. They found only a slight curvilinear effect in the early growth period. The linear regression was very near the average daily gain for this period. There was a pronounced curvilinear effect of age on gain in the second period.

Older calves generally weigh more at weaning than younger calves. During the early stages of lactation, the older calves are heavier; however, as lactation progresses they tend to lose this weight advantage. The rate of gain increases up to a point in the lactation period and then decreases as the calf becomes older. The point and rate of decrease will depend upon milk flow, grazing conditions and availability of supplemental creep feed.

Period of Lactation

Gifford (1953) found that maximum milk yield and butterfat production in beef cows were obtained in the first month of lactation. The lactation curve for cows in this study did not follow the normally reported curve for dairy cattle, but declined beginning with the first month and continued at an ever decreasing rate until the end of lactation. With spring-calving beef cows, Drewry et al. (1959) divided the lactation period into three milk sampling periods and found that milk production increased from the first period to the second period (14.1 lb. vs. 16.0 lb. per day) and decreased in the third period to a yield (9.0 lb.) less than that obtained in the first.

Neville (1962) concluded that the value of milk and its relationship to calf gains is greatest during the first 60 days of the calf's life. Riggs (1969) also stated that the influence of milk yield on gain appears greater in the early months of the calf's life. This is mainly because the total nutritive requirement of the calf increases as he gets larger while the cow's milk production decreases and becomes inadequate to supply the requirement.

Marlowe et al. (1965) reported that calves born in the period February to May gained 4% faster than the calves born in January and June, 12% faster than July to October calves and 6% faster than November and December calves. Apparently, the supply of forage stimulates milk flow during periods showing greatest gain. Todd et al. (1969) reported that when estimates of milk production were made on several breeds of dams in April and June, daily gains of calves increased from period one to period two, even though milk production generally decreased. Apparently, calves utilized sources of nutrients other than milk to provide for body growth and maintenance during the latter period.

The shape of the milk production curve and the exact time of peak yield is influenced by availability of supplemental feed and grazing conditions. Correlations between milk yield and calf gain are higher in the early stages of lactation than in the latter stages. This indicates that the calf is more dependent on milk as a nutrient source in early life and relies on forage to a greater degree as he becomes older.

CHAPTER III

MATERIALS AND METHODS

Animals, Treatments and Procedures

Treatments were initiated in the fall of 1957 (Group 1) and 1958 (Group 2) with weanling heifers to study the effects of different levels of winter nutrition for the beef female on growth and body development, reproductive performance, milk production and preweaning performance of offspring. All females utilized in the experiment were produced in the commercial Hereford herd and were sired by purebred Hereford bulls at the Fort Reno Livestock Research Station, El Reno, Oklahoma. All phases of the experiment were conducted at the same location. Native pastures used in this experiment were of the tallgrass type, containing little bluestem (*Andropogon scorpaius*), big bluestem (*Andropogon gerardi*), Indian (*Sorghastrum nutans*) and switch (*Panicum virgatum*) grasses as the predominant climax species.

In each year (1957 and 1958) four lots of 15 weanling Hereford heifer calves per lot, a total of 60, were started on test, resulting in a total of 120 experimental animals. Initial weight and age were 475 lb. and 8 months, respectively. Heifers were allotted to treatments on the basis of sire, age, body weight, conformation grade and dam's average productivity.

The four treatments employed are described as Low, Moderate, High and Very High levels of winter nutrition. The Low, Moderate and High levels were attained by varying the quantities of supplemental cottonseed cake and ground milo fed from early November to mid-April to produce a predetermined weight change pattern. The desired weight change patterns for the period November 1 to mid-April, including weight loss at calving, are described below:

First winter as calves:

Low level - no gain during the winter period.

Moderate level - 0.5 lb. gain per head per day.

High level - 1.0 lb. gain per head per day.

Second and subsequent winters as pregnant-lactating females:

Low level - loss of approximately 20% of fall body weight.

Moderate level - loss of approximately 10% of fall body weight.

High level - no weight loss.

Females in the Very High group were self-fed a 65% concentrate ration for the first two winters in Group 1 and for the first winter in Group 2. Thereafter, a 50% concentrate ration was fed (Table 1). The Very High level heifers in Group 1 were changed to the Moderate level for the fourth and subsequent winters to determine the effects of a reduction in supplemental winter feed following a period of rapid gain. This treatment combination is referred to as the Very High Moderate level. The Very High level females in Group 2 were changed from a self-fed regime to a fixed quantity of supplement consisting of 4 lb. cottonseed meal and 6 lb. ground milo per head daily for the seventh and subsequent winters; however, designation of treatment remained as the Very High level.

TABLE I

COMPOSITION OF THE RATIONS SELF-FED TO FEMALES IN THE VERY HIGH LEVEL GROUPS

Ingredient, %	Concentrate level, %	
	65	50
Ground milo	49.7	33.2
Cottonseed meal	7.7	9.5
Molasses	7.0	7.0
Chopped alfalfa	17.5	25.0
Cottonseed hulls	17.5	25.0
Ground limestone	0.6	0.3

Winter body weight changes, expressed as a percentage of fall body weight for each treatment, are presented in Table II. Due to varying weather conditions during the winter and the fact that all cows within each treatment group did not calve each year, it was difficult to maintain the desired weight change pattern. During the second through the tenth winter of treatment, the average weight losses were 21.1, 14.3, and 9.7% for Low, Moderate and High level cows, respectively. In the fourth through the tenth winter of treatment, the Very High Moderate cows lost an average of 16.6% of fall body weight.

All females were weighed at 2-week intervals during the winter feeding period, and subsequent supplemental feed consumption was adjusted in an attempt to obtain the predetermined weight gain or loss. The females in the Low level group were confined to drylot for 5 or 6 days each week during the initial part of each winter feeding period and were fed wheat straw to initiate the desired weight loss. After this initial period, they were maintained on native grass pasture. Females in the other groups were maintained on native grass pasture the entire winter. All females had free-choice access to a mineral mixture of two parts salt and one part steamed bone meal throughout the year, and all groups grazed native pasture during the summer months. During winter and summer grazing, groups were rotated among pastures in an attempt to minimize pasture effect on performance.

TABLE II

WINTER WEIGHT CHANGE EXPRESSED AS A PERCENTAGE OF FALL BODY WEIGHT FOR COWS FED DIFFERENT LEVELS OF WINTER NUTRITION

	Treatment				
Winter of treatment	Low	Moderate	High	Very High	Very High Moderate
1	-2.53	20.55	30.87	58.05	
2	-27.16	-14.11	-9.43	19.30	
3	-18.19	-7.95	-5.21	11.49	
4	-15.57	-10.39	-6.48	21.56	-21.81
5	-20.63	-15.65	-12.07	13.40	-15.01
6	-21.25	-20.68	-12.67	13.75	-17.44
7	-26.97	-19.79	-10.51	-7.27	-19.08
8	-18.21	-15.54	-9.03	-9.61	-15.78
9	-20.36	-12.70	-9.13	-3.68	-15.69
10	-21.24	-11.96	-12.56		-11.31

The average quantities of supplemental feed provided per female for each level of wintering for ten successive wintering periods are presented in Table III. To further define the conditions under which the experimental animals were maintained, the average temperature and total rainfall values for the months April through September of the years 1957 through 1967 are shown in Figure 1. Temperature and rainfall data for all months in these same years are presented in Appendix Table XXVII.

Heifers calved first as two-year-olds, and all females were pasture-mated to purebred Hereford bulls throughout the experiment. The breeding season began on May 1 and ended on August 15 each year. In order to minimize sire effect, equal numbers of heifers from each treatment group were exposed to the same bull during the breeding season.

Cows were culled from the herd on the basis of health or failure to conceive for two consecutive years.

Calves were identified by ear tags and ear tattoo and were weighed to the nearest pound within 24 hours after birth. Birth weights of heifers were corrected to a bull equivalent by multiplying by 1.048 (Smithson, 1966). Calving date, sex, dam and sire were also recorded. All calves were dehorned and vaccinated for blackleg. Bull calves were castrated at 6 to 8 weeks of age. Calves remained with their dams on native pasture until they were weaned in October. Creep feeding was not practiced at any time during the experiment. Calf weights were obtained after a 12-hour shrink at monthly intervals during lactation. Age-corrected weaning weights were obtained by use of the formula

$$\left(\frac{\text{actual weaning weight-actual birth weight}}{\text{age in days}}\right) 210 + \text{actual birth weight.}$$

The age-corrected weaning weight of the heifer calves was then corrected to a steer equivalent by multiplying by 1.059 (Smithson, 1966).

TABLE III

SUPPLEMENTAL FEED (LB.) PROVIDED PER COW FOR EACH LEVEL OF WINTERING DURING TEN SUCCESSIVE WINTERING PERIODS[a]

Winter on Treatment	Treatment									
	Low[b]		Moderate[c]		High[c]		Very High[c]		Very High Moderate[c]	
	CSC[d]	Milo	CSC	Milo	CSC	Milo	Mixed Ration		Mixed Ration	
1	52	39	275	259	389	732	3428			
2	59	36	310	136	356	640	4990			
3	55		238	81	396	753	5160			
									CSC	Milo
4	38		225	29	389	643	6951		202	56
5	61		255	29	255	635	6154		249	
6	80		258	34	242	569	6371		262	62
							CSC	Milo		
7	61		236		291	699	224	672[e]	252	
8	41		208		277	621	270	1050	213	
9	42		210		279	624	288	975	202	
10	39		218		288	602			218	

[a]A portion of this data was obtained from Smithson *et al.* (1966).

[b]Supplemental feeds provided during a period of approximately 100 days from early January.

[c]Supplemental feeds provided during a period of approximately 150 days from mid-November.

[d]CSC represents cottonseed cake.

[e]Cows on the Very High level also received 867 lb. of mixed ration during the first month of the seventh winter.

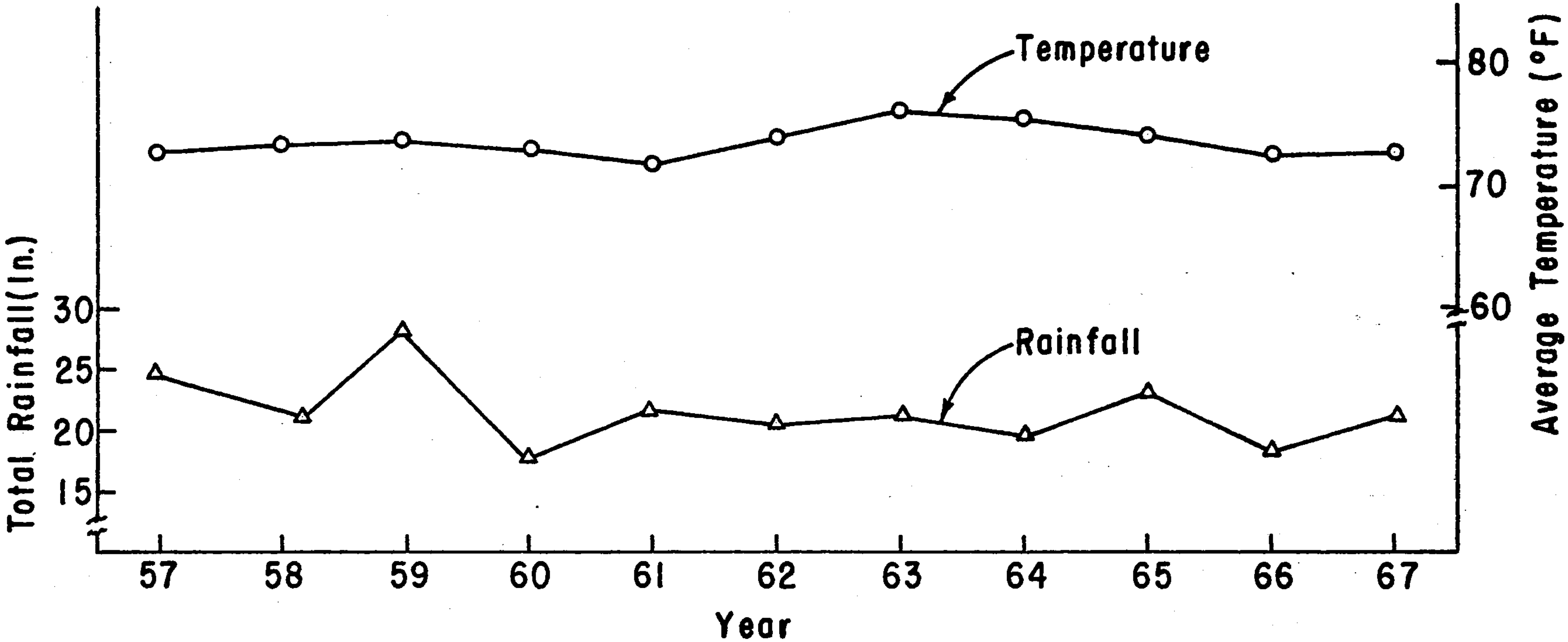

Figure 1. Average Temperature and Total Rainfall at El Reno, Oklahoma, for the Period April Through September for the Years 1957 Through 1967

The estimated 24-hour milk production of the cows was determined by the calf-suckle method at approximately monthly intervals during lactation. Calves were separated from their dams for three successive 8-hour periods (first month of each lactation) or two successive 12-hour periods (second and subsequent months of each lactation) and then weighed to the nearest 0.25 lb. immediately before and after nursing. The weight gain for the two or three periods were combined to give a 24-hour estimate of milk production. Pens and scales facilitated rapid weighing so that weight losses due to urination and defecation were minimized. Estimates of milk production were not determined for the females in Group 1 while they were nursing their first, second and fourth calves nor for the females in Group 2 while they were nursing their first calf.

Each year fall body weights were obtained for all females in early November, and spring weights were taken in April. Eight body measurements were determined on each female at the time of weighing. Height at the withers, depth of chest, distance from chest floor to ground, and length of body (point of shoulder to pin bone) were measured from photographs of the females taken while they were standing behind a metal grid. Circumference of heart girth, width of loin (immediately posterior to the last rib), width at the hips (across widest part of tuber coxae) and width of the pin bones (across widest part of tuber ischii) were measured while the female was confined in a squeeze chute. The circumference of the heart girth was measured with a steel tape, while the remaining measurements were determined by use of metal calipers. Body measurements were not obtained on the females in Group 1 in the spring of 1962 and in the spring and the fall of 1963, nor on the females in Group 2 in the spring of 1962 and 1963. The Very High level females in Group 2 were not measured in the fall of 1963. In the analyses of body weights and measurements, only data from cows which calved the previous spring were used in the fall analyses and only data from cows which calved that particular spring prior to spring weighing were used in the spring analyses.

The chronological winter on treatment, the age of dam, and the calf crop number are all expressed on a calendar year basis in Table IV.

TABLE IV

WINTER ON TREATMENT, AGE OF FEMALE AND CALF CROP NUMBER ON CALENDAR YEAR BASIS FOR FEMALES IN GROUPS 1 AND 2

	Calendar Year										
	'57	'58	'59	'60	'61	'62	'63	'64	'65	'66	'67
Winter on treatment											
Group 1	1	2	3	4	5	6	7	8	9	10	11
Group 2		1	2	3	4	5	6	7	8	9	10
Age of female, years											
Group 1	(8 mo.)	1	2	3	4	5	6	7	8	9	10
Group 2		(8 mo.)	1	2	3	4	5	6	7	8	9
Calf crop number											
Group 1			1[a]	2[a]	3	4[a]	5	6	7	8	9
Group 2				1[a]	2	3	4	5	6	7	8

[a]Indicates lactations during which milk production and calf weight data were not collected.

Statistical Analyses

Calf Weights and Milk Production

The calf weights and the 24-hour estimates of milk production obtained at each monthly milk production measurement during lactation were analyzed on a within-estimate of milk production - within-year basis by the abbreviated Doolittle method of obtaining least squares constants (Steel and Torrie, 1960). This method of analysis was used due to the multiple classification and the unequal subclass numbers. Estimates of the constants were obtained by solving a set of simultaneous equations represented by $(X'X)\beta = (X'Y)$ where X is the observation matrix, X' is the transpose of the observation matrix, Y is the vector of the observations and β is the vector of the least squares constants. The restriction employed in solving the equations was that one effect within each independent variable was set equal to zero. These effects are so indicated in the description of the model. Least squares constants obtained under this restriction were expressed as deviations from the effects set equal to zero.

Estimates of the least squares constants were obtained by solving the equation $\beta = (X'X)^{-1}(X'Y)$. Standard errors were calculated for all constants by the formula Standard Error = $\sqrt{C_{ii}\sigma^2}$ with C_{ii} being the appropriate diagonal inverse element for the constant in question and σ^2 being the residual mean square obtained from the analysis of variance.

The weights of calves from cows in Groups 1 and 2 and the 24-hour estimates of milk production for these same cows at a given monthly estimate of milk production and in any given year during which milk production data were obtained were considered to be the sum of the effects represented by the following model;

$$Y_{ijkl} = \mu + A_i + \beta_1(X_1 - 70) + B_j + C_k + e_{ijkl}$$

where,

Y_{ijkl} = individual calf weight or individual 24-hour estimate of milk production.

μ = mean calf weight of estimate of milk production for a cow in the younger group receiving the Moderate level of nutrition and nursing male calf born on day 70.

A_i = a constant for the age of dam effect with i = 1 (younger cow), 2 (older cow) and 1 set equal to zero.

β_1 = a regression coefficient for the effect of calf's birth date, x_1, a covariable, with day 70 being the estimated average birth date.

B_j = a constant for the effect of sex of calf with j = 1 (male), 2 (female) and 1 set equal to zero.

C_k = a constant for the effect of treatment of dam with k = 1 (Moderate level), 2 (Low level), 3 (High level), 4 (Very High level), 5 (Very High Moderate level) with 1 set equal to zero.

e_{ijkl} = failure of the above model to estimate calf weight or milk production.

Therefore, the approach of the analysis was to determine the effects of the variables under consideration in relation to the mean of a cow (base cow) in the younger group (started on treatments in 1958) which was receiving the Moderate level of nutrition and which was nursing a male calf born on day 70. As mentioned previously, analyses were conducted for each monthly estimate within each lactation where data were available.

In the analyses of variance, sums of squares were obtained for each variable in the model. However, due to the type of analysis (abbreviated Doolittle) and the model utilized, only the sum of squares for the last variable in the model was adjusted for everything else in the model. Thus, only F tests for the effects of treatment of dam on calf weight and milk production were conducted.

All least squares constants (k_i) were then tested for significant difference from zero by the method outlined in Steel and Torrie (1960) with $t = \frac{k_i}{s_{bi}}$; t being the calculated t value, k_i being the least squares constant under consideration and s_{bi} being the standard error corresponding to that constant.

The days of the year on which milk production estimates were obtained in years 1961 through 1967 are shown in Table V. The day of the year on which respective milk production estimates one through seven were taken varied from year to year. For example milk production estimate number one in 1961 was taken on day 110 while estimate number one in 1962 was determined on day 67. Since the earliest estimate was made on day 67, the lactation period for all years was divided into seven approximately 30-day periods beginning with day 67 and ending with day 281. Periods were designated 1, 2, 3, 4, 5, 6 and 7 and the corresponding ranges in days of the year were 67 to 97, 98 to 127, 128 to 157, 158 to 188, 189 to 219, 220 to 250 and 251 to 281, respectively. Milk production estimates within each year were then classified into periods of lactation based on the day the estimate was taken and the days of the year included in each period of lactation (Table VI). For example, milk production estimate number one in 1961 was taken on day 110; therefore, it was classified into lactation period two. This classification of the milk production and calf weight data was done in order that comparisons over years would be between cows in a similar stage of lactation, nursing calves of a similar age and grazing grasses in a comparable stage of growth.

TABLE V

DAY OF YEAR ON WHICH MILK PRODUCTION ESTIMATES WERE DETERMINED IN YEARS 1961 THROUGH 1967

Year	Estimate Number						
	1	2	3	4	5	6	7
1961	110	155	188	218	245		
1962	67	100	137	184	219	250	274
1963	85	138	171	211	254		
1964	93	128	161	192	216	247	
1965	106	141	180	204	232	278	
1966	81	111	146	165	200	229	258
1967	83	116	139	168	202	228	256

For clarification, the sequential estimates of milk production, ranging from five to seven within a given year, are referred to as estimates, while the 30-day periods within the lactations for all years are referred to as periods of lactation.

Least squares means for the daily milk production of cows on different levels of winter nutrition were calculated for periods of lactation within years by adding the least squares constant for the

TABLE VI

CLASSIFICATION OF MILK PRODUCTION ESTIMATES WITHIN EACH YEAR INTO APPROXIMATELY 30-DAY PERIODS OF LACTATION FOR YEARS 1961 THROUGH 1967 WITH AVERAGE CALF AGE (DAYS) IN PARENTHESES

Period of Lactation Day of Year Range	1 67-97	2 98-127	3 128-157	4 158-188	5 189-219	6 220-250	7 251-281
Year							
1961		1 (44)	2 (86)	3 (119)	4 (148)	5 (175)	
1962	1 (16)	2 (30)	3 (73)	4 (120)	5 (155)	6 (186)	7 (210)
1963	1 (31)		2 (79)	3 (110)	4 (149)		5 (192)
1964	1 (34)	2 (64)	3[a] (94)	4[a] (125)	5 (149)	6 (180)	
1965		1 (46)	2 (79)	3 (118)	4 (142)	5 (170)	6 (215)
1966	1 (23)	2 (49)	3 (77)	4 (96)	5 (131)	6 (160)	7 (189)
1967	1 (27)	2 (57)	3 (73)	4 (102)	5 (136)	6 (161)	7 (190)

[a]Milk production estimates 3 and 4 in 1964 were assigned to lactation periods 3 and 4, respectively, in order to keep two estimates from being in one lactation period.

the respective treatment to the value of μ for the period of lactation under consideration. Standard errors for these least squares means were calculated by the formula S.E. = $\sqrt{(C_{11} + C_{kk} + 2C_{1k})\sigma_e^2}$ where C_{11} and C_{kk} are the corresponding diagonal elements of the inverse matrix, C_{1k} is the off-diagonal element and σ^2 is the residual mean square. Element C_{11} corresponds to μ. The same procedure was used to calculate least squares means and standard errors for calf weights within periods of lactation.

Calf Birth Date, Sex-Corrected Calf Birth Weight, Age- and Sex-Corrected Calf Weaning Weight and Calf Average Daily Gain

Data for calf birth date, sex-corrected calf birth weight, age- and sex-corrected calf weaning weight and calf average daily gain (unadjusted) were analyzed on a within-calf-crop basis, which resulted in a separate analysis for each variable in each calf crop. Data from calf crops one through eight for Group 1 were analyzed with data from the corresponding calf crop for Group 2. For example, birth date data for calf crop one (1959) in Group 1 cows were analyzed with birth date data from calf crop one (1960) in Group 2 cows. Cows in Group 1 had just weaned calf crop nine and cows in Group 2 had weaned calf crop eight when collection of data for this thesis was terminated. Therefore, data for calf crop nine contains only observations for calves from cows in Group 1.

The data for each of the four variables were analyzed by the Hierarchial classification (Steel and Torrie, 1960) in order to obtain treatment means, observations per treatment mean, total sum of squares, treatment sum of squares (unadjusted for group) and the within cell sum of squares. The data were then subjected to a least squares analysis of variance utilizing the abbreviated Doolittle method (Steel and Torrie, 1960) to obtain treatment sum of squares adjusted for group where groups one and two were calves from cows in Group 1 and Group 2, respectively. This analysis of variance also yielded total sum of squares, group sum of squares (unadjusted for treatment) and residual sum of squares. The within cell sum of squares was subtracted from the residual sum of squares to obtain an estimate of the group x treatment interaction. Degrees of freedom for the interaction were calculated by (Groups - 1) (Treatments - 1) - e, where e equals the number of empty cells. Sum of squares for group corrected for treatments was calculated by the formula Group SS(Adjusted) = Group SS (Unadjusted) + Treatment SS(Adjusted) - Treatment SS(Unadjusted). The within cell error mean square was utilized to test the significance of groups (adjusted for treatments), treatments (adjusted for groups) and group x treatment interaction. The standard error for each treatment mean within each calf crop was calculated by the formula $S.E. = \sqrt{\sigma_e^2/N}$ where σ_e^2 is the within cell error mean square and N is the number of observations contained in each mean.

Since the experiment contained only two replications, there was a certain amount of confounding of age of dam and year effect with calf crop which could not be adequately separated. Therefore, analyses combining data across calf crops one through nine were not conducted.

Cow Body Weights and Body Measurements

The years 1957 through 1967 correspond to the years of treatment one through 11 for cows in Group 1 and the years 1958 through 1967 correspond to years of treatment one through 10 for cows in Group 2. Cow body weights and body measurements were analyzed on a within-season (spring and fall) within-year of treatment basis. Data from year of treatment one through 10 for cows in Group 1 were analyzed with data for the corresponding year of treatment for cows in Group 2. For example, cow weight and body measurement data for Group 1 females in 1957 (year of treatment one) were analyzed with data for Group 2 females in 1958 (year of treatment one). The same procedure was used in each season in each year of treatment thereafter. Data for the eleventh year of treatment included only observations from cows in Group 1. The statistical methods utilized were similar to those used in the analysis of calf performance data. Prior to the analysis with the abbreviated Doolittle method to obtain treatment sum of squares corrected for groups, the number of observations for the nine variables (body weight and eight body measurements) within a season within a year for a given treatment were equalized by random removal of observations within the treatment. This facilitated the analysis of all nine variables for a particular season with one pass through the computer since the same X'X matrix could be used for all variables. The number of observations removed from any one season's data did not exceed a total of five from an approximate total of 90 observations. The treatment (adjusted for groups) mean squares were tested for significance by use of the residual mean square obtained from the least squares analysis of variance.

CHAPTER IV

RESULTS AND DISCUSSION

It should be pointed out that the same cows were maintained on respective winter treatments from year to year, and the data were collected from a maximum of 120 females. In order to gain information about the cumulative effects of winter nutrition on growth and development, milk production and calf performance data had to be collected on the same cows year after year. In other words, the data for each year or each calf crop are not data from a random sample selected from the Hereford cow population each year. If, by chance, one group of females was better than the other at the time of randomization of the heifers into respective treatment groups, then the subsequent data may be biased. Therefore, these limitations must be considered in drawing conclusions from the data in this manuscript.

Milk Production and Calf Weights

The effects of different levels of winter nutrition for beef cows were compared on the basis of 24-hour milk production and calf weights within period of lactation within year for the calf crops in 1961 through 1967. An attempt was also made to determine the effects of age of dam, birth date of calf and sex of calf on these two variables. In many cases, the least squares constants for the various factors under consideration were not significantly different from zero; and in the majority of the periods, treatment effects on milk production and calf weights were not statistically significant as determined by analysis of variance. However, the effects of all factors are discussed since definite trends are evident in the data.

The average birth date (day of the year) of the calves and the subdivisions of the observations for each milk production estimate in years 1961 through 1967 are shown in Appendix Tables XXVIII through XXXIV. These values also apply to the calf weight data.

Standard errors of μ values and of least squares constants from the analyses of milk production and calf weight data appear in Appendix Tables XXXV through XLI.

Milk Production

The values of μ (base cow = younger cow receiving the moderate level of winter nutrition and nursing a bull calf born on day 70) for 24-hour milk production for periods of lactation in years 1961 through 1967 are contained in Table VII. The values tended to increase with age through 1967 when cows in the younger group were 9 years of age. Maximum production was attained in the second or third period of lactation and then tended to decrease. The increase may have been influenced by grazing conditions. Similar values for Hereford cows were reported by Gleddie and Berg (1968), while Melton et al. (1967a) reported lower values.

Age of Dam

The least squares constants for the effect of age of dam on 24-hour milk production are presented in Table VIII. Only one of the constants

TABLE VII

VALUES OF μ FOR 24-HOUR MILK PRODUCTION (LB.)
FOR PERIODS OF LACTATION IN YEARS
1961 THROUGH 1967

Period of Lactation	1	2	3	4	5	6	7
Year							
1961		12.39	11.67	10.51	8.91	7.88	
1962[a]	11.64	16.14	12.75	13.16	9.62	8.92	9.75
1963	13.58		15.76	14.05	11.86		9.98
1964	15.13	16.14	14.89	12.44	10.19	11.83	
1965		14.63	15.60	15.18	12.82	10.97	7.23
1966	14.62	16.72	16.08	14.76	13.01	8.86	9.84
1967	13.99	16.72	15.48	16.07	13.55	12.88	10.58

[a]Milk production estimates were not obtained for the older cows in 1962.

TABLE VIII

LEAST SQUARES CONSTANTS FOR EFFECT OF AGE OF DAM ON 24-HOUR MILK PRODUCTION (LB.) WITHIN PERIOD OF LACTATION WITHIN YEAR (OLDER COW-YOUNGER COW)

Period of Lactation			1	2	3	4	5	6	7
Year	Age(yr.)	Calf Crop							
1961	4 vs 3	3 & 2		0.41	0.78	0.68	0.97	1.48*	
1962[a]									
1963	6 vs 5	5 & 4	0.08		-0.19	0.08	-0.53		-0.10
1964	7 vs 6	6 & 5	-1.11	-0.43	-0.69	0.13	-0.34	-1.46	
1965	8 vs 7	7 & 6		-1.39	-0.81	-1.77	-0.88	-0.46	-0.47
1966	9 vs 8	8 & 7	0.08	-0.56	-1.18	-1.09	-0.40	-0.75	-1.67
1967	10 vs 9	9 & 8	-1.48	-1.42	-0.42	-0.83	-0.07	-0.09	-1.46

*$P < .05$, significantly different from zero.

[a]Milk production estimates were not obtained for the older cows in 1962.

(period 6, 1961) was significantly ($P < .05$) different from zero. Since the age difference in any given lactation was only 1 year, large differences in milk production were not expected. All of the constants in 1961 were positive, which indicates that older cows gave more milk than younger cows (4 vs. 3 years). During the years 1964 through 1967, the younger cows produced more milk than the older cows in all periods except period one in 1966. These data do not show that the older cows reached maximum production in any lactation. They only indicate that the differences between the groups were minimum in 1963 and that the younger group surpassed the older group in 1964. Once the younger group obtained the advantage, they maintained it through 1967. If the two groups were of equal genetic potential for milk production, then the younger cows would not be expected to surpass the older cows until the latter group had reached maximum production and had started to decline. Therefore, the younger group may have had a greater genetic potential for milk production and surpassed the older group at an earlier age than expected.

In order to further observe the effect of age of dam on milk production, least squares means were calculated by adding the least squares constants to the respective μ values for each lactation period. Average milk production for old and young groups were then calculated for each year by averaging the least squares means for periods two through five. These average milk production values are shown graphically in Figure 2. The production pattern follows that described for the least squares constants. The graph shows that average milk production was still increasing when the older and younger groups were 10 and 9 years of age, respectively. The only explanation for the reduction in

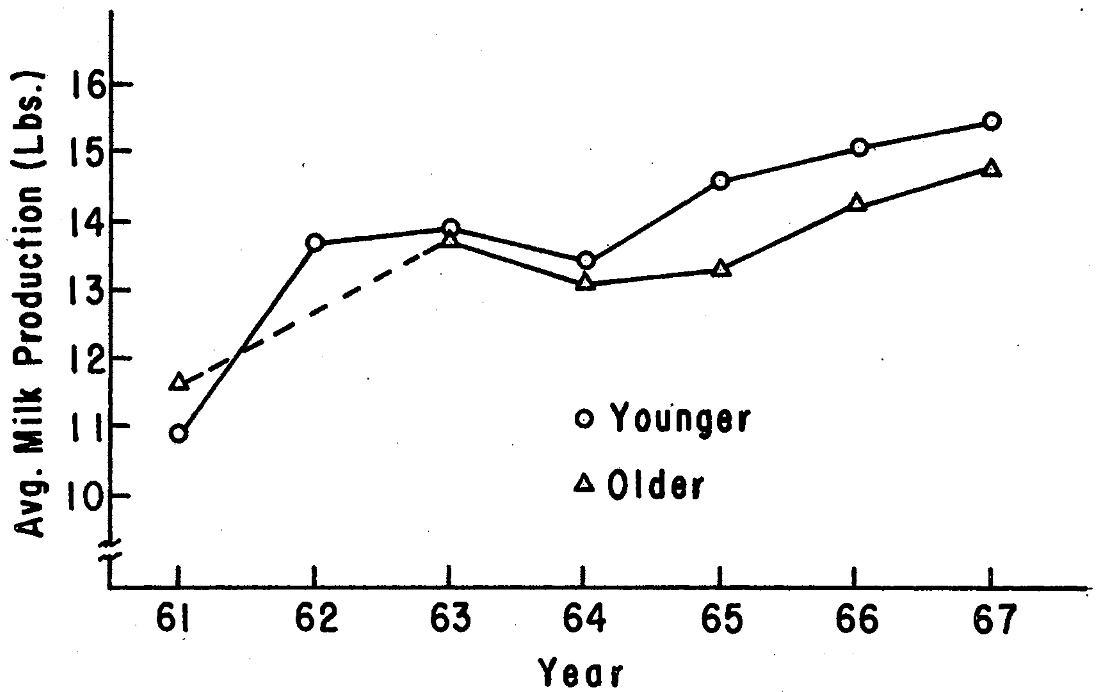

Figure 2. Average Milk Production of Older and Younger Cows for Years 1961 Through 1967

milk yield in 1964 is a severe winter prior to lactation and/or poor grazing conditions during lactation. Todd et al. (1969) observed that milk yields in beef cattle increased with age from 3 to 6 years, plateaued between 7 to 9 years and declined at 10 years. Riggs (1969) stated that milk production increases as age of beef cows increases to 8 years. In drawing conclusions from Figure 2, it appears that under proper management and good grazing conditions, increased milk production can be attained in range beef cows up to 10 years of age; however, a portion of this increase may have been due to milder winters and better grazing conditions in the latter years.

Birth Date of Calf

Table IX contains the least squares constants for the effect of calf birth date on milk production. The majority of the constants are positive and indicate that at the time the estimates were taken, cows which calved later in the season were producing more milk than cows which calves earlier. Cows which calved earlier reached a peak in production earlier and started to decline while the later calving cows were approaching peak production. Since the later calving cows were in an earlier stage of lactation, they were probably better able to respond to the lush pasture which became available in April and May. Marlowe et al. (1965) observed that calves born in months of abundant forage gained faster than calves born during months with poor grazing conditions. They concluded that the lush forage stimulated milk flow in periods showing the greatest gain.

TABLE IX

LEAST SQUARES CONSTANTS FOR EFFECT OF BIRTH DATE ON 24-HOUR MILK PRODUCTION (LB.) WITHIN PERIOD OF LACTATION WITHIN YEAR (BIRTH DATE-70)

Period of Lactation		1	2	3	4	5	6	7
Year	Calf Crop							
1961	3 & 2		0.062^{**}	0.060^{**}	0.054^{**}	0.054^{**}	0.068^{***}	
1962[a]	3	-0.162	-0.119	-0.008	-0.015	-0.038	-0.021	-0.054
1963	5 & 4	0.007		-0.002	0.048^{*}	0.077^{***}		0.052^{**}
1964	6 & 5	0.067^{*}	0.007	0.009	0.019	0.023	0.026	
1965	7 & 6		0.045	0.063^{*}	0.064^{*}	0.062^{**}	0.067^{**}	0.065^{**}
1966	8 & 7	0.038	0.009	-0.007	0.035^{*}	0.044^{*}	-0.023	0.052^{*}
1967	9 & 8	0.062	0.085^{*}	-0.002	0.031	0.029	0.028	0.038^{*}

$^{*}P < .05$, significantly different from zero.

$^{**}P < .01$, significantly different from zero.

$^{***}P < .001$, significantly different from zero.

[a]Milk production estimates were not obtained for the older cows in 1962.

Sex of Calf

The effects of sex of calf on milk production as measured by least squares constants (Table X) are illustrated in Figure 3. No apparent trend in magnitude of effect was observed over periods within year; however, a striking trend exists when the constants for a given period are studied over years. From 1961 through 1963, all but one of the constants are negative, which indicates that cows nursing male calves were giving more milk than those nursing heifer calves. In 1964, the advantage alternated between cows with male and female calves. From 1965 through 1967, all but two of the constants are positive, which reveals that cows nursing heifer calves gave more milk.

The reason for this pattern in milk production is difficult to explain. It was first thought that the male calf nursed more frequently than the heifer did as long as the dam met a greater portion of the male calf's nutrient demand. Once the cow failed to meet this requirement, as would be the case with older cows in declining milk production, the male calf tended to satisfy a larger portion of his requirement with forage while the heifer calf, in turn, continued to nurse her dam. If milk production began to decline at the time of the reverse in advantage of production due to sex of calf (1963 to 1964), then this hypothesis would have merit. However, as seen in Figure 2, even though average milk production decreased in 1964, it increased during the following three years to levels higher than those observed previously. Therefore, the hypothesis must be discarded as a possible explanation for the milk production pattern resulting from sex of calf effects.

Melton _et al_. (1967a), in a study with cows ranging in age from 2 to 10 years, reported that cows nursing bull calves gave 0.58 kg more

TABLE X

LEAST SQUARES CONSTANTS FOR EFFECT OF SEX OF CALF ON 24-HOUR MILK PRODUCTION (LB.) WITHIN PERIOD OF LACTATION WITHIN YEAR (FEMALE-MALE)

Period of Lactation		1	2	3	4	5	6	7
Year	Calf Crop							
1961	3 & 2		-0.89	-0.11	-0.71	-0.85	-1.06	
1962[a]	3	-3.81*	-1.25	-1.70	-0.92	0.13	-0.38	-1.11
1963	5 & 4	-0.58		-1.84*	-1.54*	-0.49		-0.61
1964	6 & 5	-0.38	-0.19	0.78	-0.03	0.71	-0.38	
1965	7 & 6		0.90	0.84	1.11	0.66	1.02	1.41
1966	8 & 7	-0.32	0.06	1.05	0.38	-0.18	0.77	1.36
1967	9 & 8	1.12	1.54	1.57	0.40	0.39	0.00	0.56

*$P < .05$, significantly different from zero.

[a]Milk production estimates were not obtained for the older cows in 1962.

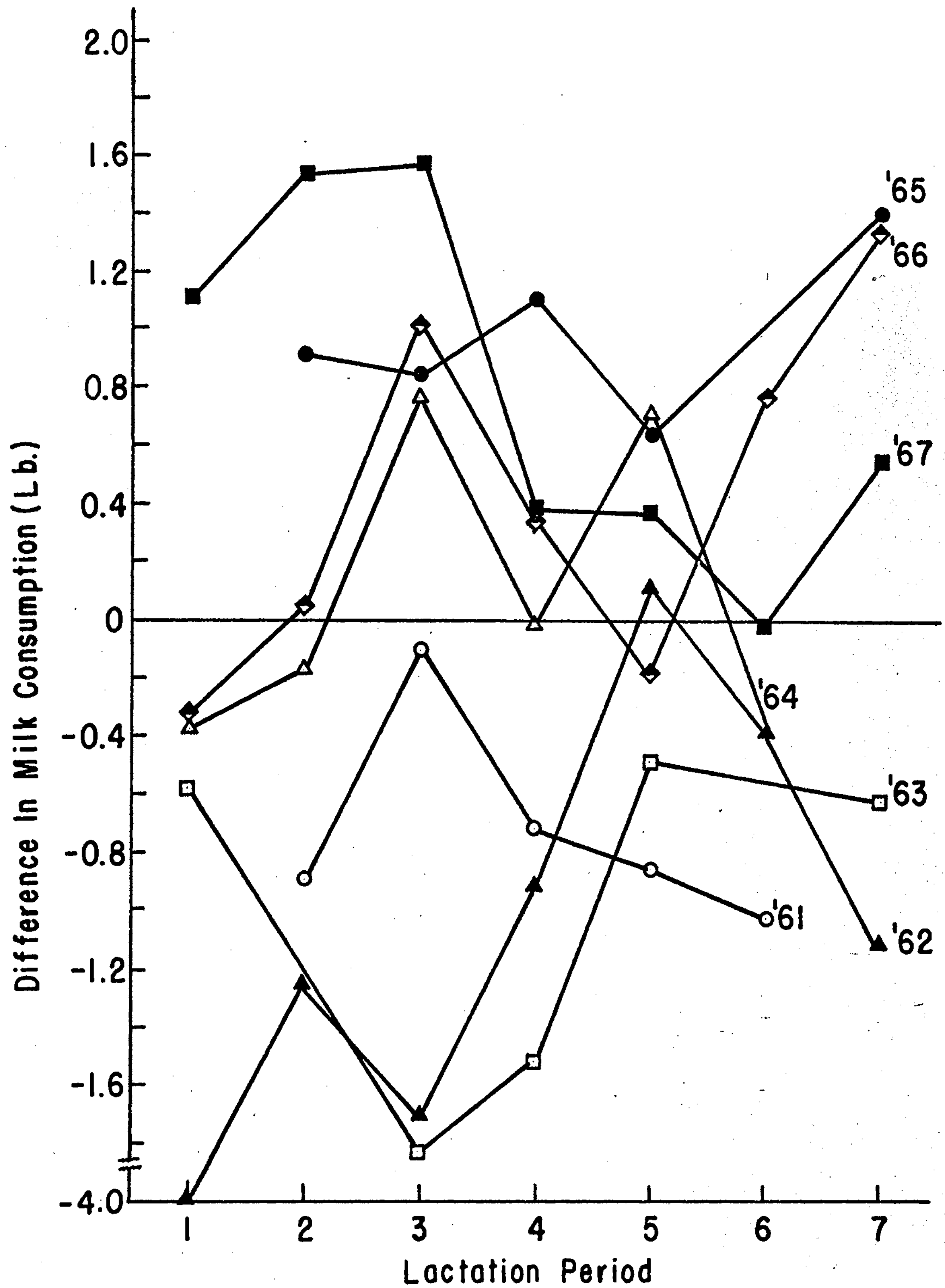

Figure 3. Least Squares Constants for Effect of Sex of Calf on Milk Production in Periods of Lactation in Years 1961 Through 1967 (Female-Male)

milk per day than cows nursing heifer calves during the first period of lactation (average of 77 days after parturition), and this decreased to 0.10 kg during the last period. The advantage in average total 175-day milk production of cows nursing bull calves over those nursing heifer calves was approximately 53 kg. Cartwright and Carpenter (1961) concluded that male calves nurse more frequently than heifer calves. This may account for the increased milk production of cows nursing male calves since Peterson (1942) reported that removal of milk from the udder reduces pressure within the udder and enhances milk secretion. The literature contains limited data concerning milk production of the same beef cows over more than the first four lactations. From the data presented in Figure 3 and Table X, it would appear that there may be an age of dam X sex of calf interaction for milk production in beef cows. Also year effect, to include severity of winter and grazing conditions of the summer, cannot be omitted as a possible factor in the milk production pattern observed due to sex of calf.

Treatment of Dam

Table XI shows the levels of significance for effects of treatment of the dam on milk production within period of lactation within year. F tests were conducted with mean squares obtained from the least squares analyses of variance described in the Materials and Methods section. Significant differences due to different levels of winter nutrition appeared to be more frequent in the earlier lactations and in the earlier periods of lactation. A discussion of this pattern will be included in the discussion of the least squares constants for each treatment.

TABLE XI

LEVELS OF SIGNIFICANCE FOR EFFECTS OF TREATMENT OF DAM ON 24-HOUR MILK PRODUCTION WITHIN PERIOD OF LACTATION WITHIN YEAR

Period of Lactation	1	2	3	4	5	6	7
Year							
1961		$P<.01$	NS[a]	$P<.05$	$P<.05$	NS	
1962	NS	NS	NS	NS	NS	NS	NS
1963	$P<.001$		$P<.05$	$P<.01$	$P<.05$		NS
1964	$P<.001$	$P<.05$	NS	NS	NS	NS	
1965		NS	NS	NS	NS	NS	NS
1966	NS	NS	NS	NS	NS	NS	NS
1967	$P<.005$	$P<.05$	NS	NS	NS	$P<.05$	NS

[a]NS = nonsignificant ($P>.05$).

The least squares constants for the effects of level of wintering on milk production of cows receiving the Low, High, Very High and Very High Moderate levels of winter nutrition are presented in Tables XII, XIII, XIV and XV, respectively. Adjusted mean values for the "base cow" were presented in Table VII. In order to more adequately discuss the trends and the meaning of the constants for the various treatments, average values for each year and for each period of lactation were calculated by averaging all constants within a respective year over periods of lactation and within a respective period of lactation over years.

The constants for the cows receiving the Low level of nutrition (Table XII) indicate that this treatment resulted in less milk production than the Moderate level at all of the estimates except two. Significant values were relatively few, and they appeared in the earlier periods of lactation. Average values for the constants within periods and over years ranged from - .81 to -1.86 lb., with larger differences usually appearing in the earlier periods. The average values for years decreased from -2.29 lb. for 1961 to - .69 lb. for 1967. Therefore, the differences in milk production appeared to decrease as the cows became older. During the early periods of lactation and before lush grass was available, the Moderate cows probably had a greater body reserve of nutrients from which to draw for milk production.

Due to the nature of the treatments, Low level cows lost more weight during the winter; however, it was observed that they gained more weight than the Moderate level cows during the summer. Gregory et al. (1950) and Brinks et al. (1962) have shown negative correlations between summer weight gains of the cow and calf gains (-.12 to -.34) and calf weaning weights (-.17). These authors concluded that cows which gain

TABLE XII

LEAST SQUARES CONSTANTS FOR EFFECT OF LEVEL OF WINTERING ON 24-HOUR MILK PRODUCTION (LB.) WITHIN PERIOD OF LACTATION WITHIN YEAR (LOW LEVEL-MODERATE LEVEL)

Period of Lactation		1	2	3	4	5	6	7
Year	Calf Crop							
1961	3 & 2		-2.90**	-1.94	-1.98	-2.17*	-2.46**	
1962[a]	3	-1.30	-4.72*	-0.72	-1.42	-1.16	-0.93	-2.41
1963	5 & 4	-2.29*		-1.59	-1.65	-1.26		-1.46
1964	6 & 5	-2.53**	-1.75	-0.86	-1.40	-0.36	-1.60	
1965	7 & 6		-0.50	-1.17	-1.35	-0.73	-0.25	-0.83
1966	8 & 7	-0.67	-1.56	-2.49	-1.35	0.51	-0.54	-1.24
1967	9 & 8	-2.53*	0.23	-0.29	0.27	-0.44	-0.93	-1.16

*$P < .05$, significantly different from zero.

**$P < .01$, significantly different from zero.

[a]Milk production estimates were not obtained for the older cows in 1962.

the most or lose the least during the grazing season produce slower gaining calves and that the cow weight gain is accomplished at the expense of milk production. Swanson and Hinton (1964) observed that feed restriction of dairy heifers to the point that they weighed 25 percent less than normal-fed heifers resulted in reduced milk production. Once the heifers were similar in body weight , then milk production was similar. They concluded that mammary development was inhibited by the underfeeding.

Some of the differences observed in the milk production of these range beef cows in the earlier lactations may have been due to differences in mammary development; however, it appears that during the latter lactations, the Low level cows utilized more of the nutrients consumed during the summer for improving body condition.

Table XIII contains the least squares constants for milk production of cows receiving the High level of winter nutrition. Again, the number of values significantly ($P < .05$) different from zero is small. Most of the values are positive, signifying that the High level cows produced more milk than the Moderate level cows at most of the milk production estimates. The differences between Moderate and High level cows were not as large as those observed between Moderate and Low level cows. As pointed out in the Materials and Methods section, the High level cows lost weight during the second and subsequent winters. Therefore, the weight loss between Low and Moderate treatments was greater than between Moderate and High treatments. This may explain the magnitude in the differences among the three groups in milk production. The average constant values for years decreased from 1.04 lb. in 1961 to -.17 lb. in 1966 and then increased to 0.73 lb. in 1967. The pattern of larger and

TABLE XIII

LEAST SQUARES CONSTANTS FOR EFFECT OF LEVEL OF WINTERING ON 24-HOUR MILK PRODUCTION (LB.) WITHIN PERIOD OF LACTATION WITHIN YEAR (HIGH LEVEL-MODERATE LEVEL)

Period of Lactation		1	2	3	4	5	6	7
Year	Calf Crop							
1961	3 & 2		1.07	1.20	1.67	1.18	0.08	
1962[a]	3	1.98	0.83	1.83	1.04	-0.63	0.03	-1.62
1963	5 & 4	2.61*		-0.05	1.26	0.63		0.10
1964	6 & 5	2.48**	0.35	-0.06	0.42	0.57	-0.53	
1965	7 & 6		-0.01	0.24	0.17	0.35	1.18	0.89
1966	8 & 7	-0.56	-1.23	-0.45	-0.05	-0.18	0.64	0.67
1967	9 & 8	1.65	2.43*	0.10	-0.06	0.41	-0.35	0.93

*$P < .05$, significantly different from zero.

**$P < .01$, significantly different from zero.

[a]Milk production estimates were not obtained for the older cows in 1962.

significant constants appearing in the first two periods of lactation which was evident with the constants for the Low level cows was also apparent in this data. The discussion presented with data where Moderate level cows exceeded the Low level cows should be applicable for the observation with the High level cows.

The Moderate level cows excelled the Very High level cows in milk production (Table XIV), and average constant values for year and period were greater than those observed between Low and Moderate and High and Moderate level cows. In contrast to the observation discussed previously, the larger negative constants were obtained in lactation periods three and four instead of one and two. The average values for constants in periods one through seven further illustrate this since they were -.59, -1.74, -1.94, -2.31, -1.43, -1.36 and -1.72 lb., respectively. It appears that the Very High level of winter nutrition had a detrimental effect on milk-secreting capacity since the differences in milk production between the Very High and Moderate level cows were largest when ample grass was available. In other words, cows which had received excessive winter nutrition from weaning were unable to produce as much milk as cows receiving reduced winter nutrition when all cows were placed in a common environment of sufficient forage.

The trend observed in the average constant values for years was also different than the trend noted in the previous treatment comparisons. Average constant values for years were smaller in 1961 and 1962 (-.37 and -1.03 lb., respectively) and increased during the next five lactations (-2.54, -1.95, -1.25, -1.77 and -2.42 lb., respectively). Since the values tended to increase to a certain extent after the first lactation, it would appear that the milk producing capacity of the

TABLE XIV

LEAST SQUARES CONSTANTS FOR EFFECT OF LEVEL OF WINTERING ON 24-HOUR MILK PRODUCTION (LB.) WITHIN PERIOD OF LACTATION WITHIN YEAR (VERY HIGH LEVEL-MODERATE LEVEL)

Period of Lactation		1	2	3	4	5	6	7
Year	Calf Crop							
1961	3 & 2		-0.51	-0.33	-1.02	-0.17	0.17	
1962[a]	3	0.21	-0.42	-0.38	-1.14	-1.45	-.179	-2.23
1963	5 & 4	-1.25		-3.89**	-3.30	-2.32		-1.98
1964	6 & 5	0.57	-3.88*	-1.97	-2.22	-0.87	-3.33*	
1965	7 & 6		-1.46	-1.76	-2.65	-1.15	1.26	-1.54
1966	8 & 7	-1.00	-2.17	-2.06	-3.46*	-1.17	-1.49	-1.06
1967	9 & 8	-1.49	-2.00	-3.38*	-2.41	-2.89	-3.00*	-1.80

*$P < .05$, significantly different from zero.

**$P < .01$, significantly different from zero.

[a]Milk production estimates were not obtained for the older cows in 1962.

Moderate level cows increased at a faster rate than the capacity of the Very High level cows. The large and consistently negative constant values in lactation periods six and seven indicate that the Moderate level cows were more persistent in milk production than the Very High level cows. An explanation of the smaller differences in production during the first period of lactation when grass was at a minimum may be the fact that the Very High cows had a greater amount of body reserve nutrients.

Swanson (1960) reported that dairy heifers which had been fed for rapid gain and fattening produced less milk in the first two lactations than twin mates which had been fed for normal growth. Examination of udders from the fattened heifers revealed areas lacking development of secretory tissue. Holland (1961) observed that beef females fed for maximum gain up to first calving produced less milk in the first lactation than twin mates fed for normal growth with differences being 2.4 lb. at 112 days of lactation and 3.8 lb. at 210 days of lactation. This latter observation also indicates that the females fed for normal growth were more persistent. Joubert (1954) reported that heifers on a low plane of nutrition began milk production at a lower level, but they maintained a greater level of persistency than heifers on a high plane of nutrition.

The Very High level cows were heavier than cows in all other treatment groups at the beginning of each lactation. Therefore, their maintenance requirement during lactation was probably higher than the maintenance requirement of the other cows (Brody, 1945). In turn, possibly a smaller portion of consumed nutrients was available for milk production. This may have been a contributing factor to the reduced milk production of the Very High level cows.

The least squares constants for the effects of winter nutrition on milk production of the cows receiving the Very High Moderate level (Table XV) reveal patterns similar to those observed with the Very High level cows. Only a limited number of the constants were significantly ($P<.05$) different from zero; however, there was a very consistent trend for the Moderate level cows to excel the Very High Moderate cows within lactations and from year to year. The average constant values for periods of lactation ranged from -.97 to -1.84 lb. and the average values for years ranged from -.44 lb. in 1961 to -2.03 lb. in 1967.

As indicated in the Materials and Methods section, the Very High Moderate cows were switched from the Very High level to the Moderate level after they had weaned their first calf. Since milk production estimates were not obtained in the first lactations of the older and the younger cows, it is difficult to determine the exact stage of development in the female at which the detrimental effect of the Very High level of nutrition was initiated. In reviewing the constants for the Very High cows (Table XIV), it can be concluded that the detrimental effect was definitely initiated prior to the second lactation. Work by Swanson (1960) and by Arnett (1963) indicates that the growth and development stage prior to the first lactation is the critical period. Holland (1961) concluded that mature cows were not as easily injured by excessive fat as developing heifers.

When the constants for the Very High and the Very High Moderate level cows are viewed simultaneously, it can be concluded that the detrimental effects of the Very High level of nutrition on milk production were permanent. Even though the Very High Moderate level cows were

TABLE XV

LEAST SQUARES CONSTANTS FOR EFFECT OF LEVEL OF WINTERING ON 24-HOUR MILK PRODUCTION (LB.) WITHIN PERIOD OF LACTATION WITHIN YEAR (VERY HIGH MODERATE LEVEL-MODERATE LEVEL)

Period of Lactation		1	2	3	4	5	6	7
Year	Calf Crop							
1961	3 & 2		-0.59	0.06	-0.26	-0.52	-0.91	
1962[a]								
1963	5 & 4	-1.66		-2.72*	-1.97	-2.66*		-1.68
1964	6 & 5	-1.58	-1.86	-0.79	-1.40	-1.39	-2.02	
1965	7 & 6		-2.48	-3.08*	-2.33	-0.88	-1.38	0.55
1966	8 & 7	-0.81	-1.28	-2.15	-1.56	-2.28	-0.30	-0.54
1967	9 & 8	-2.79	-0.41	-2.35	-0.58	-2.68	-3.17**	-2.21

*$P < .05$, significantly different from zero.

**$P < .01$, significantly different from zero.

[a]Milk production estimates were not obtained for the older cows in 1962.

maintained on the Moderate level of nutrition each winter after the first calf crop, their milk production was similar to that of the Very High cows; and it was definitely less than the production of the Moderate cows.

The weight gain and loss patterns of the cows on the various winter levels of nutrition will be discussed in the section dealing with body weights and measurements. However, it is of interest to note that the Very High Moderate cows lost considerable body weight when they were switched to the Moderate level of nutrition. In fact, average body weights of the Very High Moderate cows were slightly less than those of the Moderate cows at all spring and fall weighings after the change in treatment. This further indicates that the effect of the Very High level of nutrition on reducing milk production resulted more from impaired milk secreting capacity and not just from an increase in maintenance requirement due to increased body weight.

Least squares means for milk production of cows on Low, High, Very High and Very High Moderate levels of winter nutrition appear in Appendix Tables XLIII, XLIV, XLV and XLVI, respectively. The least squares means for all treatments for lactations in 1961 through 1967 are presented graphically in Figures 4 through 10. These graphs illustrate the differences represented by the least squares constants and, at the same time, show the adjusted average production of cows on each treatment.

Milk production means for 1961 are represented in Figure 4. With the exception of the slight increase for the Low level cows in period three, there was a fairly constant decline in milk production from the first estimate to the last estimate for cows on all treatments. The first estimate in 1961 was taken on day 110 when the average calf age

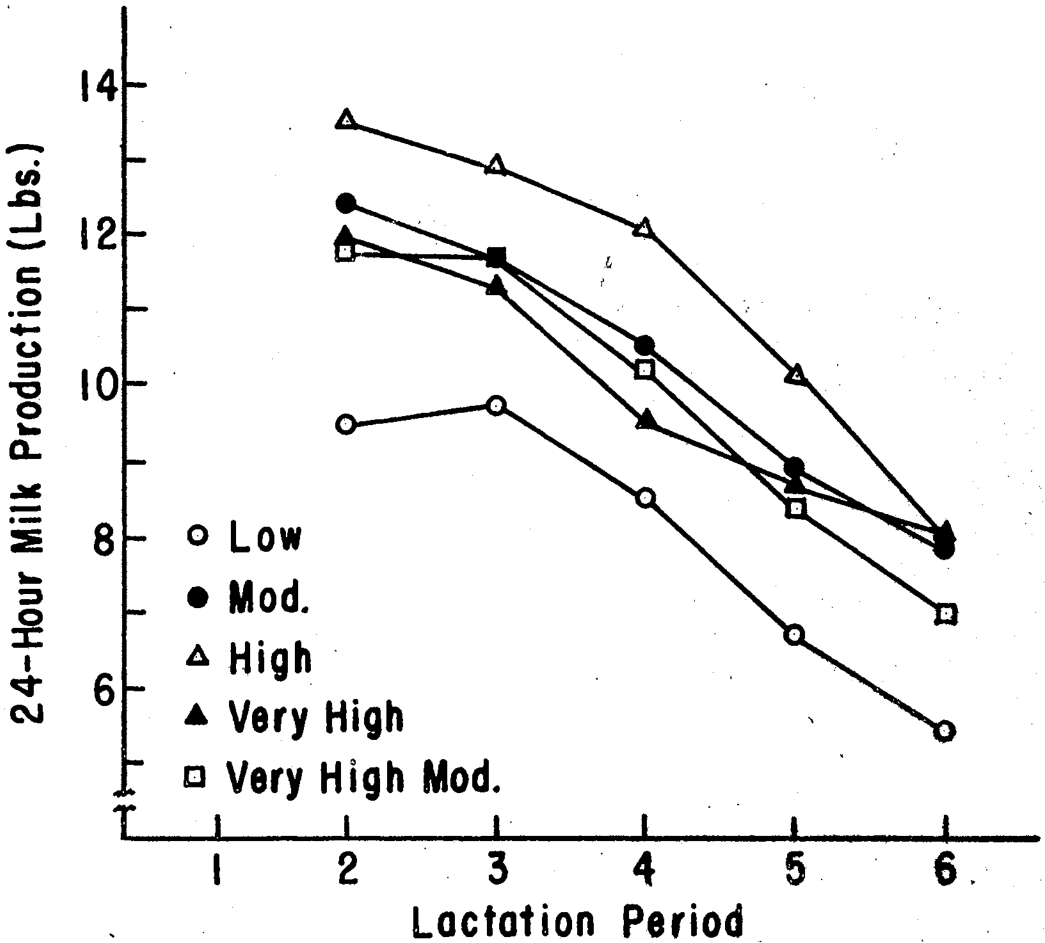

Figure 4. Least Squares Means for 1961 Milk Production Estimates of Cows Fed Different Levels of Winter Nutrition

was 44 days. This pattern does not correspond to the peak in milk production in the second month of lactation described by Dawson, Cook and Knapp (1960) and Bond and Wiltbank (1970). Melton et al. (1967a) reported a linear decline in milk production of spring-calving beef cows from day 77 to day 224 in the lactation. In regard to effects of treatment of dam on shape of the curve, Bond and Wiltbank (1970) observed that beef heifers receiving low levels of protein or energy declined in milk production as lactation progressed, while heifers receiving moderate and high levels of protein or energy peaked in production at 60 and 120 days, respectively.

The figure also points out that the production of the Low level cows was consistently lower than production of cows on all other treatments while the High level cows were consistently the highest producers. Production of the Very High and the Very High Moderate cows was usually below that of the Moderate cows.

In 1962 (Figure 5), cows in the Moderate, High and Very High groups reached maximum production in the second period of lactation (estimate on day 100, calf age 30 days), while cows on the Low level of nutrition peaked in the third period (estimate on day 137, calf age 73 days). Dunn et al. (1965) also reported variation in the stage of lactation at which cows on different levels of winter nutrition reached maximum milk production.

Increases and sharp declines were noted in the milk production curves during the remainder of the lactation in 1962 and in subsequent years. These fluctuations may have been due to weather conditions on days the estimates were taken and/or variation in the rainfall and grass conditions throughout the grazing season. It was noted that on extremely

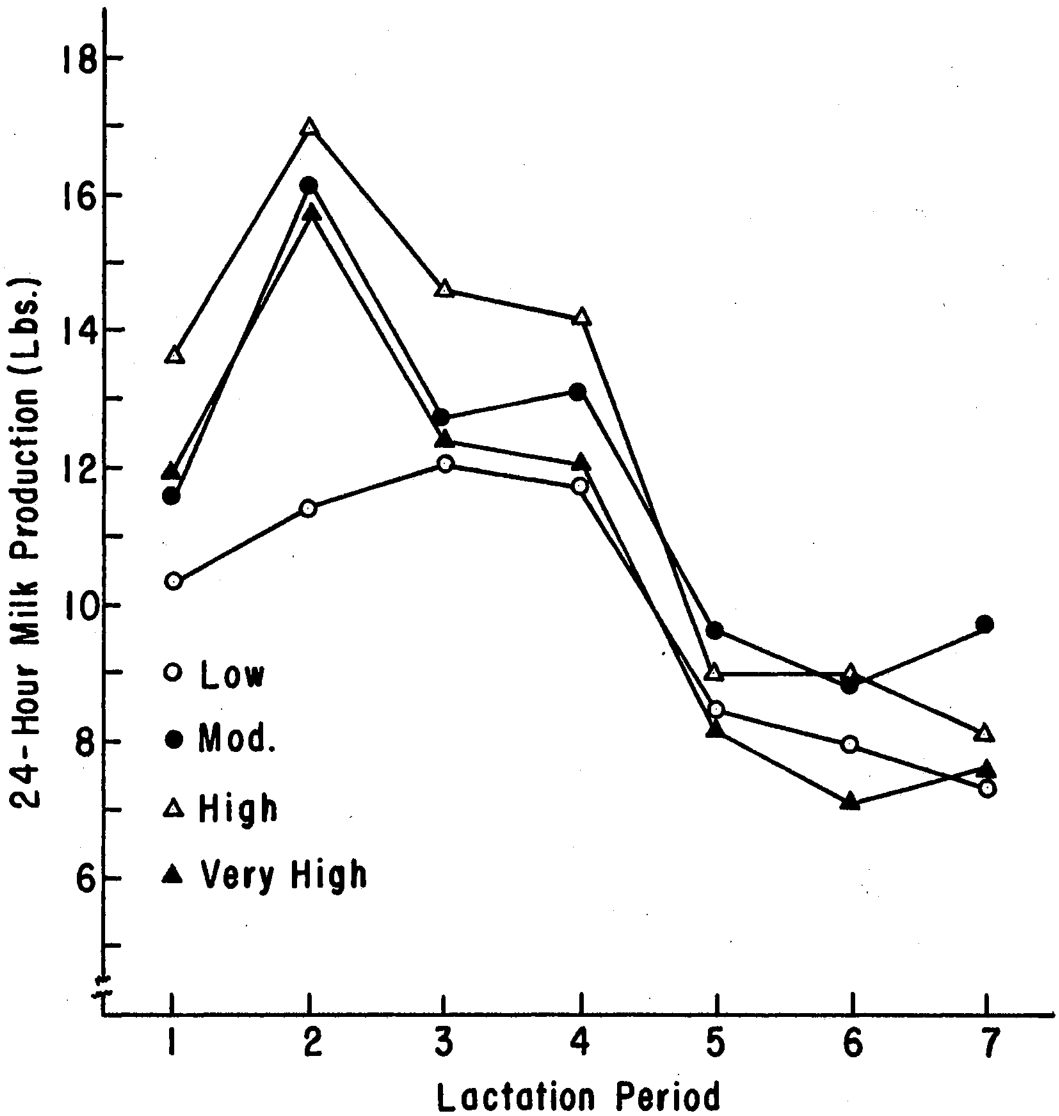

Figure 5. Least Squares Means for 1962 Milk Production Estimates of Cows Fed Different Levels of Winter Nutrition

hot days, cows remained in the shade as much as possible and grazing was reduced to a minimum. Furr and Nelson (1964) reported that the milk production of fall-calving beef cows increased with the onset of spring grazing. Harris et al. (1962) reported that spring-calving beef cows also responded to improved grazing with an increase in milk production.

In 1963 (Figure 6), when the cows were nursing fourth and fifth calves, the production of the Low level cows exceeded the production of the Very High level and the Very High Moderate level cows. As discussed previously, possibly the Low level cows were utilizing a greater portion of their nutrient intake during lactation for growth, body condition, and/or development of the milk secreting system than cows on the other treatments up to 5 years of age (fourth calf crop). Figure 6 also indicates that cows on the Very High and the Very High Moderate levels of winter nutrition produced at levels considerably lower than the Moderate and the High level cows. In absolute values, these differences were greater than those observed in 1961 and 1962. The differences in means for production in period seven reveal that High and Moderate level cows produced from 1.5 to 2.0 lb. more milk than cows on the other treatments. Milk yields of the Low, Moderate and Very High Moderate cows peaked at the third period (estimate on day 138, calf age 79 days) while yields for cows on the High and Very High treatments declined slightly from the previous estimate.

The milk production curves in 1964 (Figure 7) were rather erratic; however, the High and the Moderate level cows tended to produce more milk than cows on the other treatments. Except for period one, Low level cows produced as much or more milk than cows on the Very High and the Very High Moderate treatments. The production of the Low, Moderate

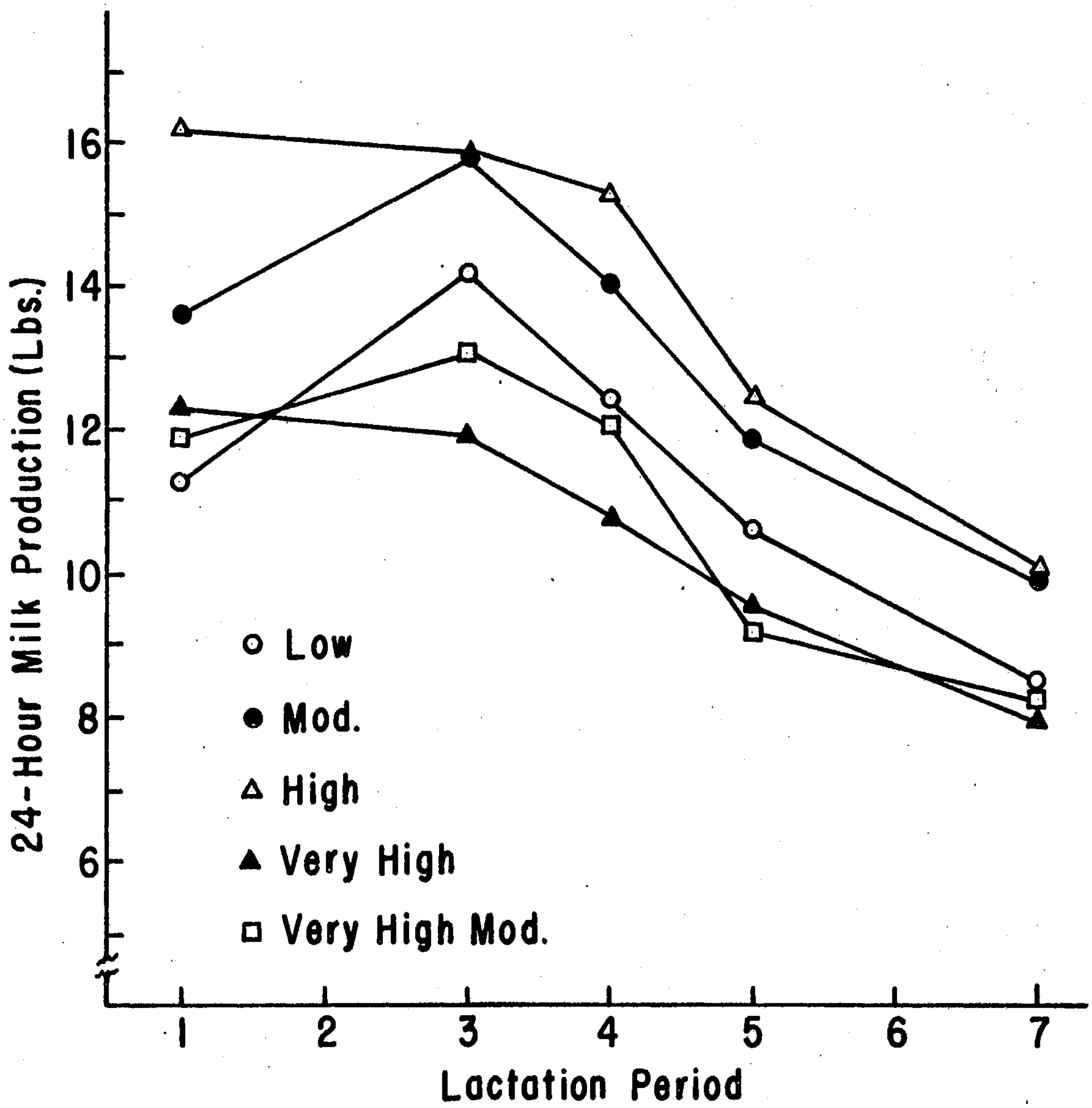

Figure 6. Least Squares Means for 1963 Milk Production Estimates of Cows Fed Different Levels of Winter Nutrition

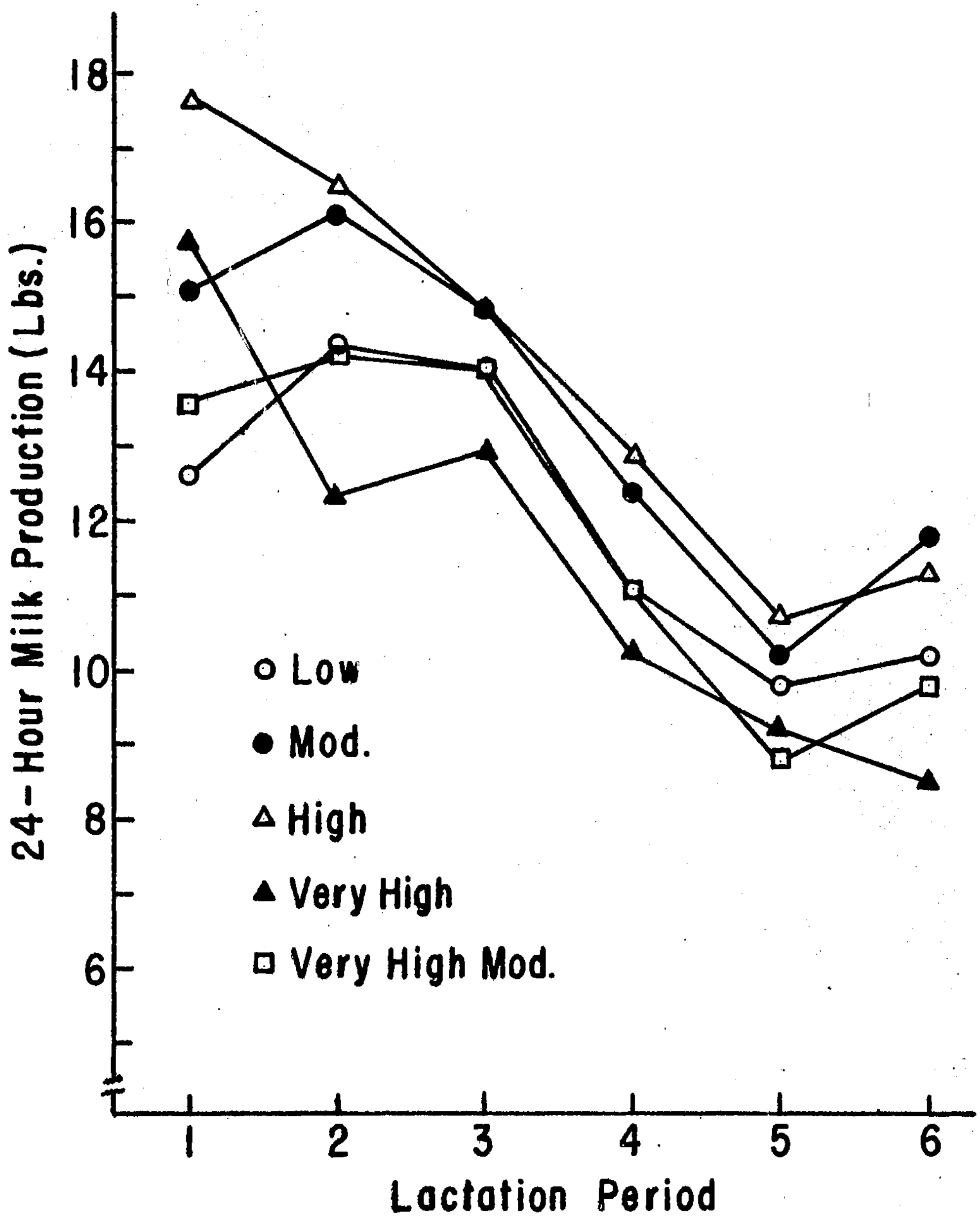

Figure 7. Least Squares Means for 1964 Milk Production Estimates of Cows Fed Different Levels of Winter Nutrition

and Very High Moderate cows showed a slight peak in lactation period two (estimate on day 128, calf age 64 days), while the production of the other groups declined.

The pattern in 1965 (Figure 8) was similar to the one observed in 1964. In the majority of the estimates, the rank in treatment group from highest to lowest production was High, Moderate, Low, Very High and Very High Moderate. For production in period seven, the ranking was High, Very High Moderate, Moderate, Low and Very High. Production of the Low, Moderate, High and Very High cows peaked in period three (estimate on day 141, calf age 79 days).

In 1966 (Figure 9), the Moderate level cows tended to produce more milk than the High level cows; however, the differences were very small. The production curves of the Very High and Very High Moderate cows were erratic and both appeared above and below the Low level curve at various periods in the lactation. Peak production occurred in period two (estimate on day 111, calf age 49 days).

The rank in milk production in 1967 (Figure 10) was similar to that observed in the two previous lactations. The pattern of production was rather unique since two distinct peaks in production were observed. All treatment groups reached maximum production in period two (estimate on day 116, calf age 57 days), and declined in period three. Another peak in production was noted in period four. It is thought that this second peak was due to improved grazing conditions.

In reviewing Figures 4 through 10, definite trends are apparent in the milk production of cows fed different levels of winter nutrition. Over the years, the High and the Moderate level cows tended to exceed cows receiving the other three treatments. The production of the Low

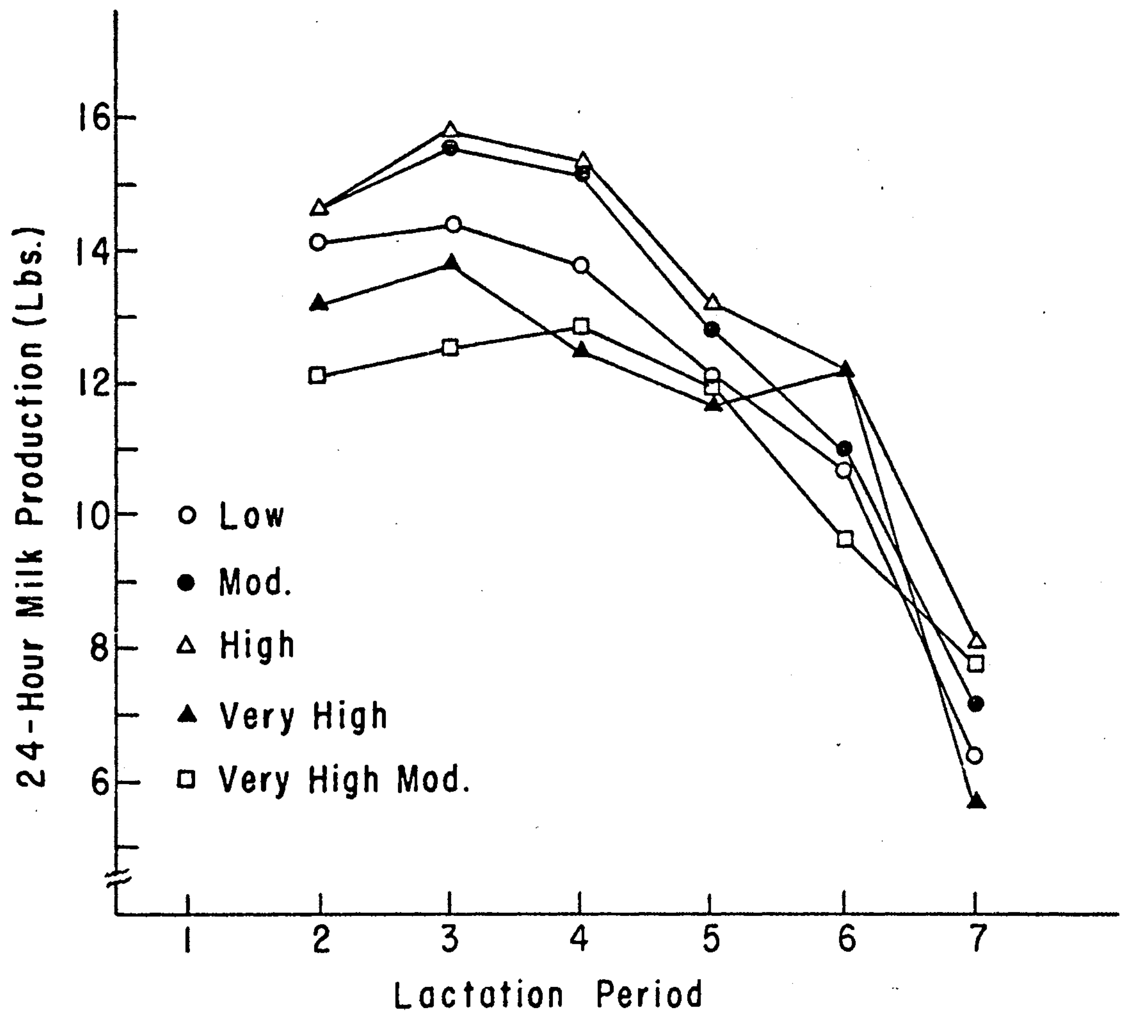

Figure 8. Least Squares Means for 1965 Milk Production Estimates of Cows Fed Different Levels of Winter Nutrition

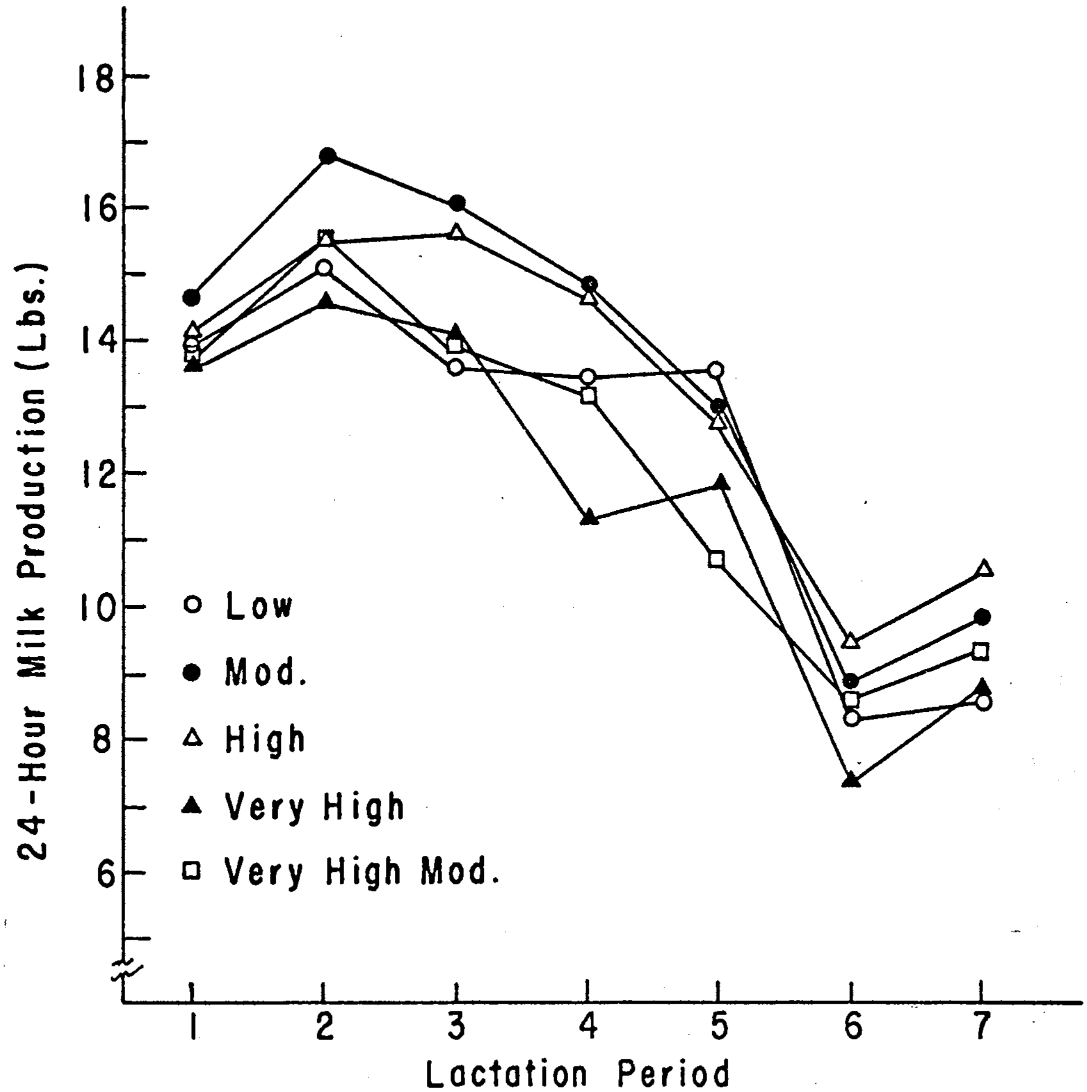

Figure 9. Least Squares Means for 1966 Milk Production Estimates of Cows Fed Different Levels of Winter Nutrition

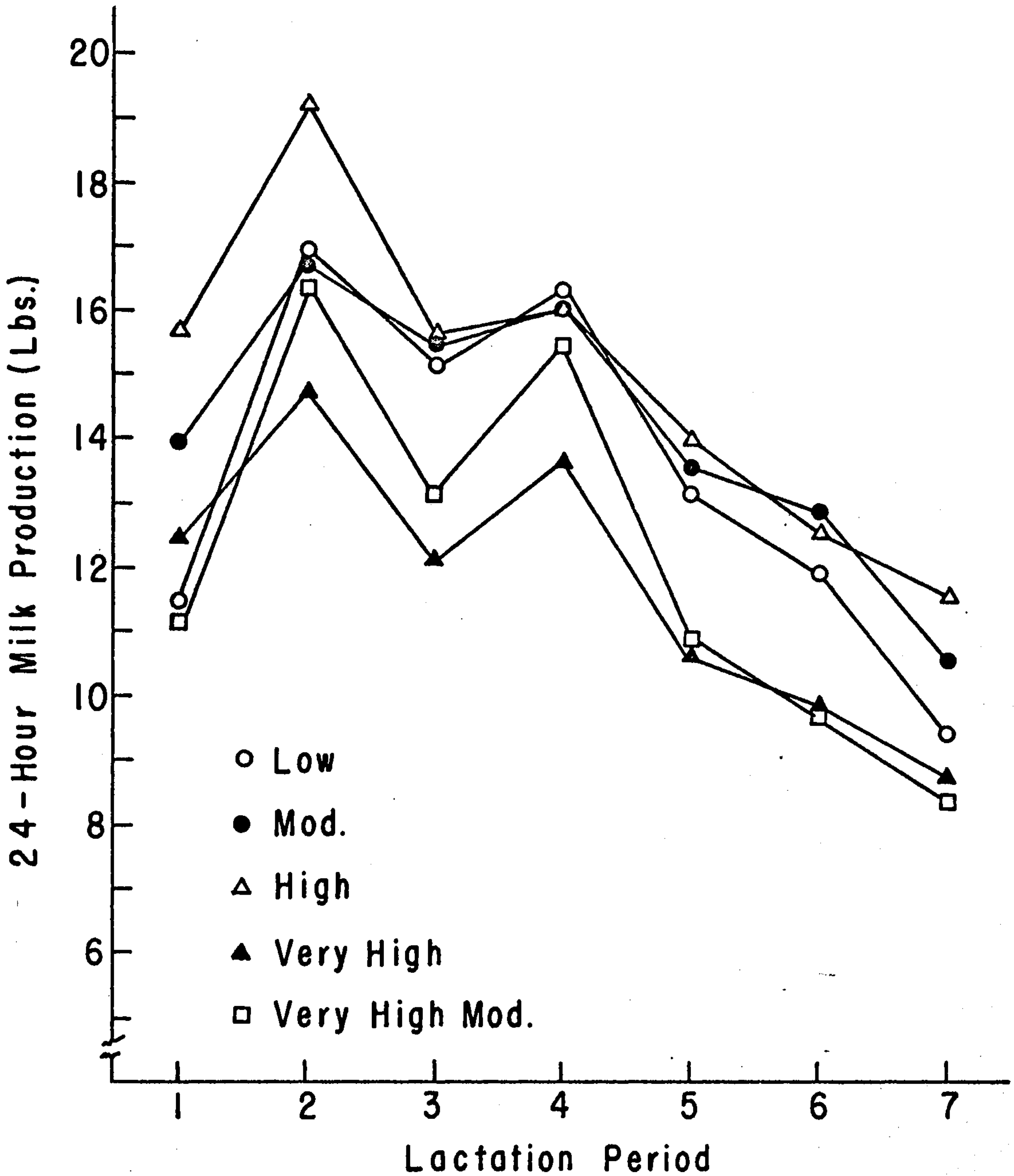

Figure 10. Least Squares Means for 1967 Milk Production Estimates of Cows Fed Different Levels of Winter Nutrition

level cows appeared to increase at a faster rate than the production of the Very High and the Very High Moderate cows up to the fourth lactation; and by this time, Low level cows were producing more milk than cows in the Very High and the Very High Moderate groups. In view of the data of Swanson (1960), Holland (1961), Arnett (1963), Reid et al. (1964) and Swanson et al. (1967), it is thought that the Low level of nutrition restricted milk production by delaying the development of the milk secretory system and the attainment of mature body weight. It is further thought that the Very High level of nutrition resulted in reduced milk secretion, possibly due to secretory tissue being replaced by fatty tissue. After the fourth calf crop, the level of restriction appeared to be greater in cows which had received the Very High level of nutrition during early development.

The occurrence of peaks in lactation varied from year to year. The range in calf age at maximum yield was 30 to 79 days. Other workers (Dunn et al., 1965; Gifford, 1953; Drewry et al., 1959; Melton et al., 1967a) have also reported considerable variation in occurrence of peaks in milk production in beef cows. It appears that severity of winter and grazing conditions in early lactation are important factors in determining the time of peak milk production.

Calf Weights

Values of μ for calf weight in periods of lactation during the years 1961 through 1967 are presented in Table XVI. These values represent the adjusted mean weight of male calves born on day 70 and nursing younger cows receiving the Moderate level of winter nutrition.

TABLE XVI

VALUES OF μ FOR CALF WEIGHT (LB.) IN
PERIODS OF LACTATION IN YEARS
1961 THROUGH 1967

Period of Lactation	1	2	3	4	5	6	7
Year							
1961		135.00	218.72	286.70	339.57	395.61	
1962[a]	86.30[a]	140.46	207.03	297.92	382.09	428.81	464.03
1963	115.05		209.30	280.38	364.51		445.48
1964	121.83	174.91	247.88	312.87	353.17	402.04	
1965		136.73	210.09	294.25	345.95	394.26	475.22
1966	100.35	153.27	227.84	269.69	338.21	386.19	449.98
1967	111.82	172.96	212.61	271.09	346.01	398.99	452.92

[a]Monthly calf weights were not obtained for calves from the older cows in 1962.

Age of Dam

The least squares constants for effect of age of dam on calf weight (Table XVII) reveal a pattern similar to that observed for the effect of age of dam on milk production (Table VIII). Even though none of the differences are significantly ($P > .05$) different from zero, the direction (positive or negative) of the difference constitutes a definite trend. In 1961, calves from the older cows (4 years of age) were heavier than calves from younger cows (3 years of age), and the difference increased in a linear fashion through the last weighing. From 1963 through 1967, calves from younger cows were heavier than older cows except at the first milk production estimate in 1966. Average constant values for periods of lactation ranged from -2.12 lb. for period one to -8.26 lb. for period seven. Since calf gains are cumulative, one would expect the greatest difference in calf weights to occur after the calves had been subjected to different levels of milk for the greatest period of time. In comparing the trends in Tables VIII and XVII, calf weights tended to follow the pattern established in milk production. It appears that level of milk production was the major influence on calf weights.

Marlowe *et al*. (1964) stated that calf gains from birth to weaning increased with cow's age from 2 to 6 years, remained approximately the same for 6 to 11 years and decreased thereafter. Godley *et al*. (1966) also observed that calves from younger cows (3 to 5 years) gained less from birth to weaning than calves from older cows (6 to 12 years of age). Jamison (1967) reported that the gain of a beef calf from birth to weaning was lowest when the dam was 2, 3, 4 or 11 years of age.

TABLE XVII

LEAST SQUARES CONSTANTS FOR EFFECT OF AGE OF DAM ON CALF WEIGHT (LB.) WITHIN PERIOD OF LACTATION WITHIN YEAR (OLDER COW-YOUNGER COW)

Period of Lactation			1	2	3	4	5	6	7
Year	Age (yr.)	Calf Crop							
1961	4 vs 3	3 & 2		1.20[a]	3.87	5.14	7.11	8.06	
1962[b]									
1963	6 vs 5	5 & 4	-1.94		-4.33	-5.68	-10.20		-6.45
1964	7 vs 6	6 & 5	-4.12	-2.75	-7.41	-7.86	-5.59	-5.41	
1965	8 vs 7	7 & 6		-4.04	-5.02	-6.50	-9.23	-9.74	-7.42
1966	9 vs 8	8 & 7	2.46	-0.81	-4.69	-5.39	-9.27	-10.54	-13.44
1967	10 vs 9	9 & 8	-4.88	-4.18	-5.96	-2.87	-4.21	-2.17	-5.71

[a]None of the constants in the table are significantly different from zero ($P > .05$).

[b]Monthly weights were not obtained for calves from the older cows in 1962.

Birth Date of Calf

Calves born later in the year weighed less at the time each milk production estimate was determined (Table XVIII). Average constant values for years did not follow any definite trend; however, average absolute values for constants were greater in the latter periods (4 to 7). This indicates that the calves were apparently gaining faster in the last half of lactation. Even though total milk yield of the beef cow usually decreases in the latter stages of lactation, the calf has also developed the ability to utilize forage. The nutrients supplied by both milk and grass may have been great enough to produce greater gains than when milk was essentially the only source of energy.

The values compare favorably with those reported by Burgess et al. (1954) and Minyard and Dinkel (1965). Marlowe and Gaines (1958) reported no significant differences in growth rate of non-creep-fed calves from 90 to 210 days of age. Marlowe (1962) found a decrease in average daily gain with an increase in calf age from 60 days to 300 days.

Sex of Calf

The least squares constants for effects of sex of calf on calf weights within periods of lactation are shown in Table XIX. Without exception, male calves were heavier than heifer calves at each weighing. The majority of the larger and significant constants appear in years 1961, 1962 and 1963. In Figure 3, it was shown that in these same years, male calves consistently consumed more milk than heifers at each estimate, while heifer calves consumed more milk in the remaining years. If, in fact, the heifer calves did consume more milk than male calves in 1964 through 1967, then male calves obtained an even greater portion of

TABLE XVIII

LEAST SQUARES CONSTANTS FOR EFFECT OF BIRTH DATE ON CALF WEIGHT (LB.) WITHIN PERIOD OF LACTATION WITHIN YEAR (BIRTH DATE-70)

Period of Lactation		1	2	3	4	5	6	7
Year	Calf Crop							
1961	3 & 2		-1.05[a]	-1.18	-1.27	-1.36	-1.31	
1962[b]		-2.51	-1.75	-1.72	-2.07	-2.11	-2.38	-2.37
1963	5 & 4	-1.67		-1.78	-1.86	-1.88		-1.90
1964	6 & 5	-1.51	-1.51	-1.73	-1.84	-1.87	-1.79	
1965	7 & 6		-1.41	-1.64	-1.74	-1.75	-1.75	-1.91
1966	8 & 7	-1.60	-1.76	-1.86	-1.82	-1.80	-1.80	-1.65
1967	9 & 8	-1.38	-1.19	-1.69	-1.82	-1.89	-1.93	-1.79

[a]All constants in the table are significantly different from zero ($P < .001$).

[b]Monthly weights were not obtained for calves from the older cows in 1962.

TABLE XIX

LEAST SQUARES CONSTANTS FOR EFFECT OF SEX OF CALF ON CALF WEIGHT (LB.) WITHIN PERIOD OF LACTATION WITHIN YEAR (FEMALE-MALE)

Period of Lactation		1	2	3	4	5	6	7
Year	Calf Crop							
1961	3 & 2		-4.65	-8.56	-14.24*	-14.81	-20.82*	
1962[a]	3	-14.42*	-16.75*	-24.42**	-32.61**	-38.16**	-42.10**	-44.20**
1963	5 & 4	-11.68**		-20.11***	-22.19**	-23.80**		-37.58***
1964	6 & 5	-4.54	-4.38	-3.62	-6.54	-8.44	-11.64	
1965	7 & 6		-4.93	-5.41	-7.26	-8.91	-11.81	-22.10*
1966	8 & 7	-3.04	-4.33	-7.82	-5.76	-8.39	-11.28	-13.60
1967	9 & 8	-6.45	-6.29	-8.89	-8.66	-12.95	-15.51	-18.53*

*$P < .05$, significantly different from zero.

**$P < .01$, significantly different from zero.

***$P < .001$, significantly different from zero.

[a]Monthly weights were not obtained for calves from the older cows in 1962.

their nutrient supply from grass and/or were more efficient in converting total energy intake to gain since they were heavier than heifers at all stages of lactation.

The average constant values for periods of lactation over years were -8.03, -6.89, -11.26, -13.89, -16.44, -18.86 and -27.20 lb. for periods one through seven, respectively. This indicates that after the first period, there appeared to be a linear increase in the difference in growth rate of male calves as compared to female calves.

The values of the constants are expressed as a positive advantage of male over female in Figure 11. In most years the rate of increase in weight advantage was greater in the second half of lactation. This is in agreement with the observation of Swiger (1961) where bull calves gained faster just prior to weaning than earlier in the lactation.

The weight advantages for the male calves are in the ranges reported by Pahnish et al. (1961) and Brown (1961), but they are larger than those reported by Burgess et al. (1954). Jamison (1967) observed that male calves had an average daily gain from birth to weaning of 0.16 lb. greater than heifers. Marlowe et al. (1965) stated that steer calves had a 6 percent faster growth rate than heifers.

Treatment of Dam

The levels of significance for effects of treatment of the dam on calf weights within periods of lactation within years are shown in Table XX. The pattern of significant effects on calf weight was similar to that noted with milk production (Table XI) in that most of the significant differences due to treatment occurred prior to 1965. Even though treatment differences were statistically significant ($P < .05$) at only

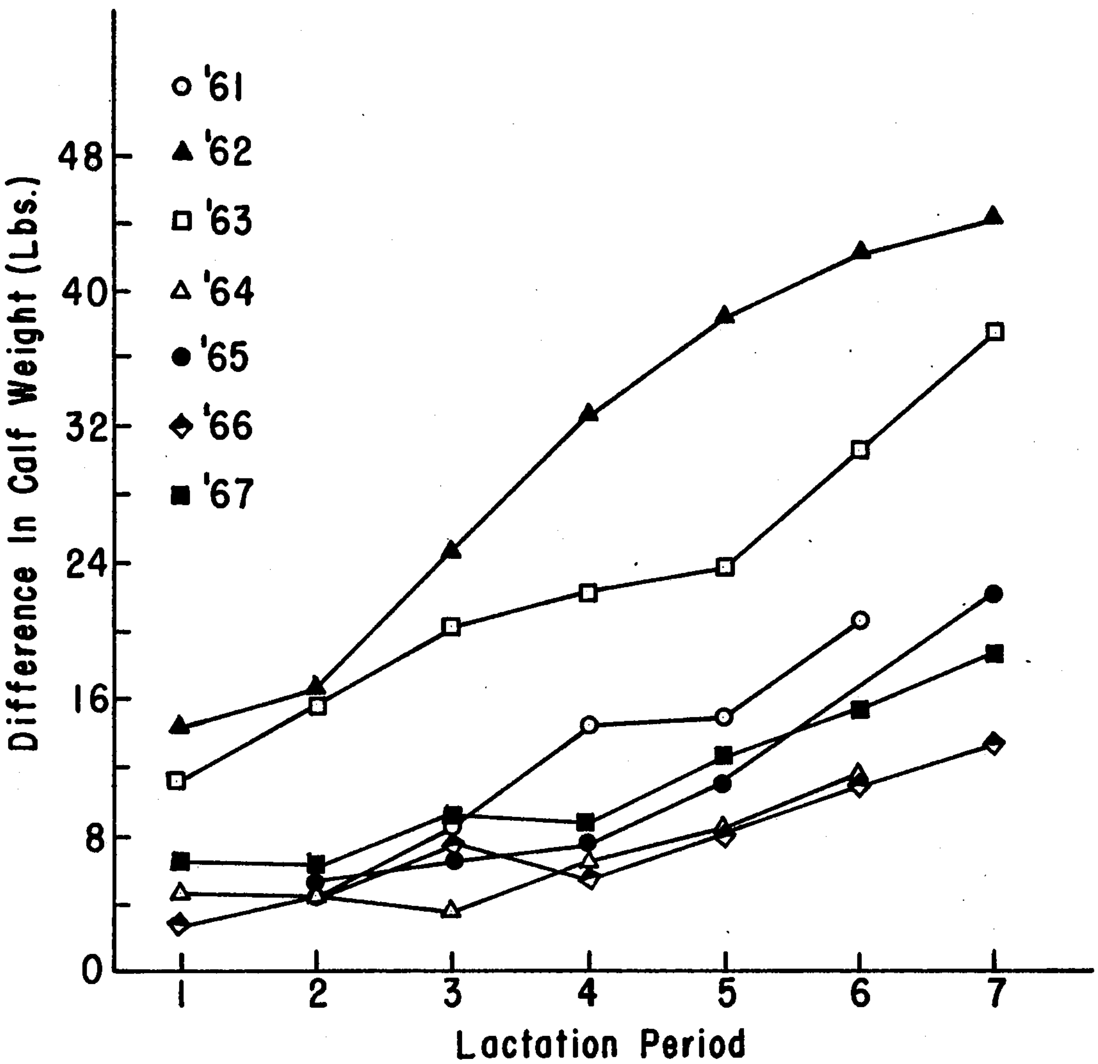

Figure 11. Weight Advantage of Male Calves Over Female Calves in Periods of Lactation in Years 1961 Through 1967

TABLE XX

LEVELS OF SIGNIFICANCE FOR EFFECTS OF TREATMENT OF DAM ON CALF WEIGHT WITHIN PERIOD OF LACTATION WITHIN YEAR

Period of Lactation	1	2	3	4	5	6	7
Year							
1961		$P<.01$	$P<.005$	$P<.05$	$P<.005$	$P<.005$	
1962	NS[a]	NS	NS	NS	NS	NS	NS
1963	$P<.005$		$P<.01$	$P<.01$	NS		$P<.05$
1964	$P<.005$	$P<.005$	$P<.005$	$P<.005$	$P<.01$	$P<.01$	
1965		$P<.01$	NS	NS	NS	NS	NS
1966	NS	NS	NS	NS	NS	NS	NS
1967	NS	NS	NS	NS	NS	NS	NS

[a]NS = nonsignificant ($P>.05$).

16 out of 43 weighings, the trends established by the least squares constants warrant presentation and discussion.

The least squares constants for weights of calves from cows on the Low level of wintering (Table XXI) indicate that with the exception of 1965, calves from the Low level cows were lighter than calves from the Moderate level cows. The weights in the latter portion of lactation (periods six and seven) represent the overall effect of treatment of dam on calf weight, and they ranged from 5.54 to -35.61 lb. The larger absolute values appeared in 1961, 1962 and 1963. It was pointed out in the discussion of Table XII that the average constant values for milk production of the Low level cows were extremely low in those same years. Therefore, it appears that the calves from the Low level cows were lighter due to restricted milk flow of the dam. Once the Low level cows had met the nutrient demand for body growth and/or development of the milk secretory system, milk production and calf weight differences between the Low level and the Moderate level cows were reduced.

Least squares constants in Table XXII indicate that calves from the High level cows were consistently heavier than calves from the Moderate level cows. No set pattern was evident in the constants in periods six and seven (3.22 to 34.75 lb.). Weight advantages observed in the early periods of lactation were maintained or increased through the last period of lactation. This may indicate that High level cows were more persistent in their milk production. The calf weight pattern tended to parallel the pattern observed for milk production.

Even though only three of the least squares constants for weight of calves from the Very High level cows (Table XXIII) were significantly ($P < .05$) different from zero, calves from the Moderate level cows were

TABLE XXI

LEAST SQUARES CONSTANTS FOR EFFECT OF LEVEL OF WINTERING OF DAM ON CALF WEIGHT (LB.) WITHIN PERIOD OF LACTATION WITHIN YEAR (LOW LEVEL-MODERATE LEVEL)

Period of Lactation		1	2	3	4	5	6	7
Year	Calf Crop							
1961	3 & 2		-15.22*	-23.84**	-27.45**	-29.71*	-35.61**	
1962[a]	3	-9.44	-10.71	-22.79	-21.18	-28.53	-17.02	-13.85
1963	5 & 4	-17.46**		-16.55*	-17.01	-15.03		-15.50
1964	6 & 5	-15.64**	-13.21*	-14.29	-14.26	-13.88	-12.13	
1965	7 & 6		-1.97	1.73	0.18	0.65	2.93	5.54
1966	8 & 7	-3.22	-9.17	-10.45	-9.18	-5.92	-3.08	-1.22
1967	9 & 8	-11.77*	-14.59*	-12.51	-11.30	-10.36	-12.58	-9.28

*$P < .05$, significantly different from zero.

**$P < .01$, significantly different from zero.

[a]Monthly weights were not obtained for calves from the older cows in 1962.

TABLE XXII

LEAST SQUARES CONSTANTS FOR EFFECT OF LEVEL OF WINTERING OF DAM ON CALF WEIGHT (LB.) WITHIN PERIOD OF LACTATION WITHIN YEAR (HIGH LEVEL-MODERATE LEVEL)

Period of Lactation		1	2	3	4	5	6	7
Year	Calf Crop							
1961	3 & 2		17.10**	18.10**	19.40*	23.59*	21.38	
1962[a]	3	0.52	-0.06	3.35	9.55	2.62	13.00	10.04
1963	5 & 4	7.28		8.07	11.92	9.94		11.11
1964	6 & 5	15.34**	21.92***	23.77**	22.68*	23.54*	27.35*	
1965	7 & 6		19.17***	16.79*	17.43	18.14	19.19	34.75*
1966	8 & 7	6.74	5.91	-0.09	0.51	0.87	3.22	5.77
1967	9 & 8	15.85**	15.83*	6.64	12.48	10.42	11.76	14.60

*$P < .05$, significantly different from zero.

**$P < .01$, significantly different from zero.

***$P < .001$, significantly different from zero.

[a]Monthly weights were not obtained for calves from the older cows in 1962.

TABLE XXIII

LEAST SQUARES CONSTANTS FOR EFFECT OF LEVEL OF WINTERING OF DAM ON CALF WEIGHT (LB.) WITHIN PERIOD OF LACTATION WITHIN YEAR (VERY HIGH LEVEL-MODERATE LEVEL)

Period of Lactation		1	2	3	4	5	6	7
Year	Calf Crop							
1961	3 & 2		-3.29	-6.71	-9.67	-8.45	-12.09	
1962[a]	3	-4.18	-16.79	-14.09	-17.17	-22.29	-18.89	-25.72
1963	5 & 4	-1.65		-21.25*	-26.69*	-22.20		-40.70*
1964	6 & 5	5.66	3.18	-9.03	-16.14	-19.09	-27.91	
1965	7 & 6		7.29	0.15	-0.44	-3.19	-0.93	4.61
1966	8 & 7	8.74	3.39	0.54	-3.89	-7.26	-9.18	-9.37
1967	9 & 8	-5.99	-4.97	-12.41	-15.26	-19.09	-21.80	-22.50

*$P < .05$, significantly different from zero.

[a]Monthly weights were not obtained for calves from the older cows in 1962.

heavier, especially in periods six and seven. The average constant values for periods ranged from 0.52 lb. in period one to -18.74 lb. in period seven. Again, this may be an indication of persistency of milk production, and the observation will be discussed at the end of the calf weight section. It was observed in 1964, 1965 and 1966 that calves from the Very High level cows were heavier during the early periods of lactation; and in 1965, calves from Very High level cows held a slight weight advantage in period seven. In the discussion on milk production, it was pointed out that smaller differences in milk yield between Very High and Moderate level cows occurred in the early portion of lactation.

Even though the absolute values were smaller, least squares constants for weights of calves from the Very High Moderate level cows (Table XXIV) portrayed a pattern similar to that observed with the Very High level calves. One exception to the previous pattern was that the Moderate level calves held a sizeable weight advantage over the Very High Moderate calves in 1965, even though the difference was not statistically significant ($P < .05$). There was a linear increase in average constant values from period two (-2.52 lb.) to period seven (-11.79 lb.).

In general, the least squares constants for calf weights reveal that calves from High level cows were usually heavier than calves from Moderate level calves at all periods of lactation, while calves from Moderate level cows were generally heavier than calves from Low, Very High and Very High Moderate level dams. Weight advantages observed in the early periods of lactation were usually maintained or increased slightly through the last period of lactation. Joubert (1954) found that the weaning weights of calves of beef breeds were significantly reduced by a low plane of winter nutrition for the dam. Furr (1959)

TABLE XXIV

LEAST SQUARES CONSTANTS FOR EFFECT OF LEVEL OF WINTERING OF DAM ON CALF WEIGHT (LB.) WITHIN PERIOD OF LACTATION WITHIN YEAR (VERY HIGH MODERATE LEVEL-MODERATE LEVEL)

Period of Lactation		1	2	3	4	5	6	7
Year	Calf Crop							
1961	3 & 2		-1.22[a]	-9.37	-12.34	-13.51	-14.12	
1962[b]	3							
1963	5 & 4	-7.46		-14.02	-8.17	-4.60		-9.58
1964	6 & 5	-2.06	0.21	-2.66	-5.36	-9.57	-11.64	
1965	7 & 6		-4.73	-3.98	-7.65	-9.89	-9.77	-14.40
1966	8 & 7	-4.79	-6.69	-8.50	-14.64	-15.48	-9.70	-15.96
1967	9 & 8	2.10	-0.15	-5.07	-5.67	-4.56	-9.19	-7.22

[a]None of the constants are significantly different from zero ($P > .05$).

[b]Monthly weights were not obtained for calves from the older cows in 1962.

observed that a high level of winter supplement (cottonseed meal plus grain) increased weaning weights by 30 lb. and 27 lb. for calves from fall-calving cows and heifers, respectively. Zimmerman (1960) reported that spring-calving Hereford heifers fed a low level of winter nutrition weaned significantly lighter calves at 210 days in the first three calf crops than heifers fed a high level of nutrition. A low plane of nutrition from prepartum period through weaning resulted in lower calf average daily gains than did high levels fed for the same period (Renbarger et al., 1964). Arnett (1963) found that beef heifers fed at a moderate level had heavier calves at weaning than did heifers on full feed. In contrast, Hobbs et al. (1965) and Marion and Hammack (1969) reported no significant difference in weaning weights of calves due to different levels of wintering for the dams. The degree to which different levels of wintering affect calf weaning weight apparently depends upon the amount of weight loss of the dam during winter and grazing conditions during lactation.

Since the calf weight patterns followed the milk production pattern of the dams, it was concluded that milk consumption was the major factor influencing weights of calves from cows receiving the different levels of winter nutrition. Sire effect and pasture conditions were equalized among treatment groups; therefore, the postnatal environments were similar except for dam's milk supply. Average constant values for periods of lactation over years revealed that the increase in weight advantage during lactation was greater for the Moderate calves over the Very High and the Very High Moderate calves than for High calves over Moderate calves or Moderate calves over Low calves. This suggests that the Very High and the Very High Moderate cows lacked persistency of milk production. It appears that cows which are in better body condition at the initiation of lactation produce more milk due to the fact that they have a greater body reserve of nutrients from which to draw or they utilize more of the consumed nutrients for milk production instead of weight gain. At the same time, excessively fat females may produce less milk, especially if the fattening process occurred during early body development. It is of importance to note here that other workers have found varying degrees of relationship between milk production and calf gain. Gifford (1953) reported correlations between daily milk production by beef cows and daily gains of their calves of 0.60, 0.71, 0.52 and 0.35 for the first, second, third and fourth months of lactation, respectively. Correlations between calf gain and milk production for the entire lactation range from 0.40 (Melton et al., 1967a) to 0.83 (Riggs, 1969). Renbarger et al. (1964) found the milk yields of beef heifers fed different levels of pre- and post-calving nutrition to be 8.2, 9.4, 9.7 and 10.7 lb., and corresponding calf average daily gains were 1.36, 1.47, 1.54 and 1.62 lb., respectively.

In comparison with the work of Howes et al. (1958), calves from cows on the various levels of winter nutrition probably received a considerable portion of their nutrient supply from grass after the second month of lactation.

Calf birth weight was not included in the statistical model; therefore, it is difficult to evaluate the influence of calf birth weight on milk production of the dam and calf weight at various periods of lactation. Gregory et al. (1950), Neville (1962) and Christian et al. (1965) reported significant correlations between calf birth weight and weaning weight, while Drewry et al. (1959) reported a significant correlation between calf birth weight and milk production of the dam. However, Christian et al. (1965) and Gleddie and Berg (1968) found no significant correlations between calf birth weight and milk production of the dam. Neville (1962) observed that calf gain to 8 months was not significantly influenced by birth weight differences.

In this study no statistically significant ($P>.05$) differences were observed in calf birth weights after the third calf crop; however, definite trends due to treatment of dam were still evident in milk yields and calf weights in subsequent lactations. It is felt that even though differences in birth weight were contributing factors to differences in calf weight in the final stage of lactation, milk production of the dam was a more important factor.

Least squares means for weights of calves from cows fed the Low, High, Very High and Very High Moderate levels of winter nutrition are presented numerically in Appendix Tables XLVII, XLVIII, XLIX and L, respectively. Least squares means for all treatments are depicted graphically in Figures 12 through 18.

In 1961 (Figure 12), mean values for weights of calves from the Low, Moderate, High, Very High and Very High Moderate cows in lactation period two were, 120, 135, 152, 132 and 134 lb., respectively, with a range in overall difference of 32 lb. Calf weights for the same treatment groups in lactation period six were, 360, 396, 417, 384 and 381 lb., respectively, with a range in overall difference of 57 lb. Therefore, the increase in weight difference between the heaviest calves (High level) and the lightest calves (Low level) was 25 lb. The data indicate that calves from all treatment groups except the Low level had similar rates of gain from period two to period six. The rank in calf weight

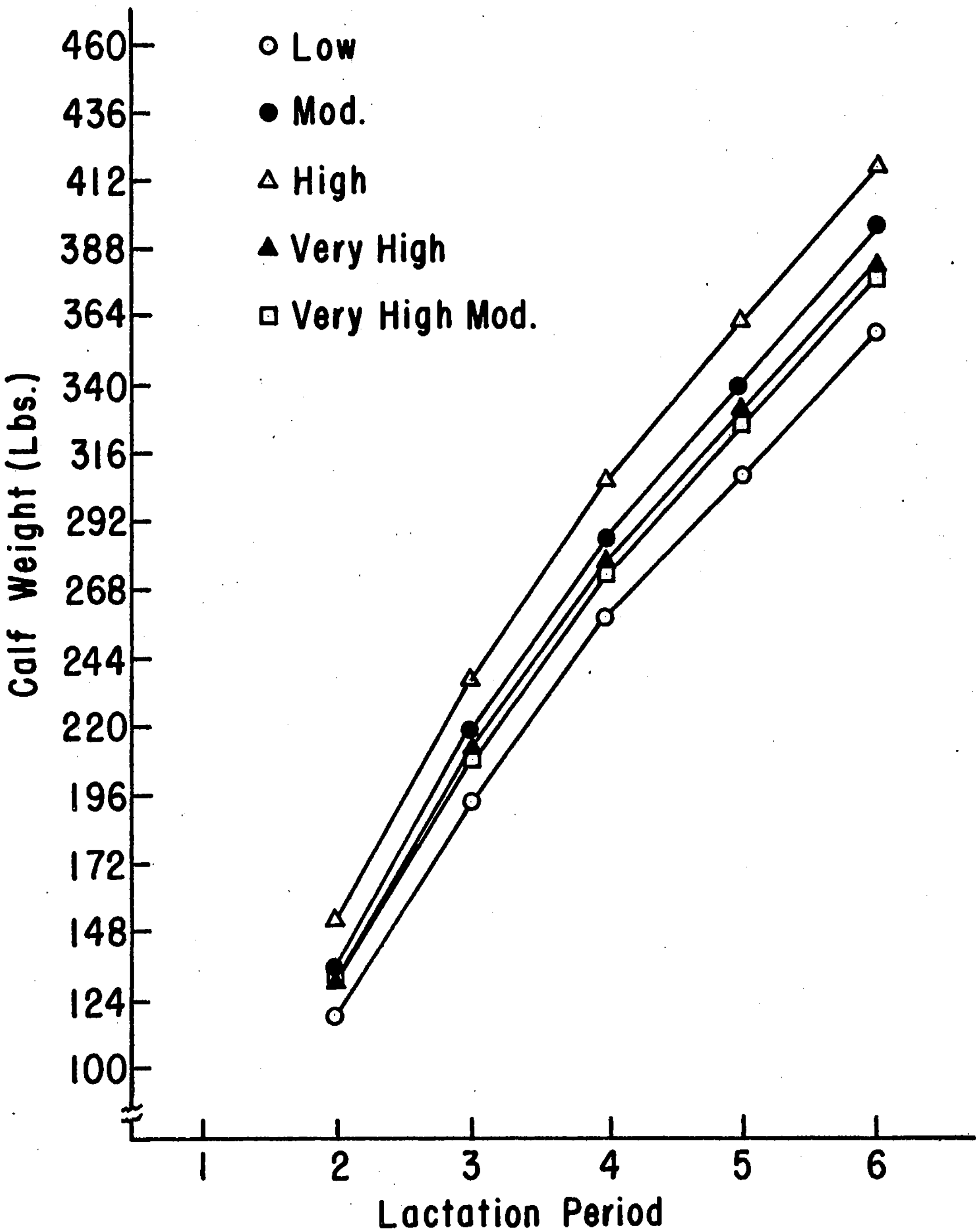

Figure 12. Least Squares Means for Calf Weight in the 1961 Calf Crop From Cows Fed Different Levels of Winter Nutrition

was the same as the rank in milk production in 1962, i.e., High > Moderate > Very High > Very High Moderate > Low.

The relative rank in calf weight for the 1962 calf crop (Figure 13) also closely followed the relative rank in milk production of the dams. Overall weight difference in the first period of lactation was 10 lb. which increased to 36 lb. in period seven. Rank in calf weight in period seven was High > Moderate > Low > Very High.

In 1963 (Figure 14), calves from the Very High level cows, gained at a slightly slower rate than calves from other treatment groups in lactation periods six and seven. It was also observed that calves from the Very High Moderate cows held a slight weight advantage over the Low calves throughout lactation even though the Low level cows yielded more milk than the Very High Moderate cows at all estimates except the first one. The reason for the Low level calves not to gain at a faster rate on the additional milk is not readily determined from these data. Calf weights in period seven were 430, 445, 457, 405 and 436 lb. for calves from Low, Moderate, High, Very High and Very High Moderate cows.

In 1964 (Figure 15), rates of growth for the High level calves and the Low level calves were almost identical. Weight differences between the two groups were 31 lb. and 39 lb. in periods one and six, respectively. Even though the Very High calves held a weight advantage over Low, Moderate and Very High Moderate calves in period one, they were the lightest calves in period six. The lower rate of growth of these calves followed the pattern of rapid decline in milk production by the dams. Calf weights in period six were 390, 402, 429, 374 and 390 lbs. for Low, Moderate, High, Very High and Very High Moderate calves, respectively.

Least squares means for calf weights in the 1965 and 1966 calf

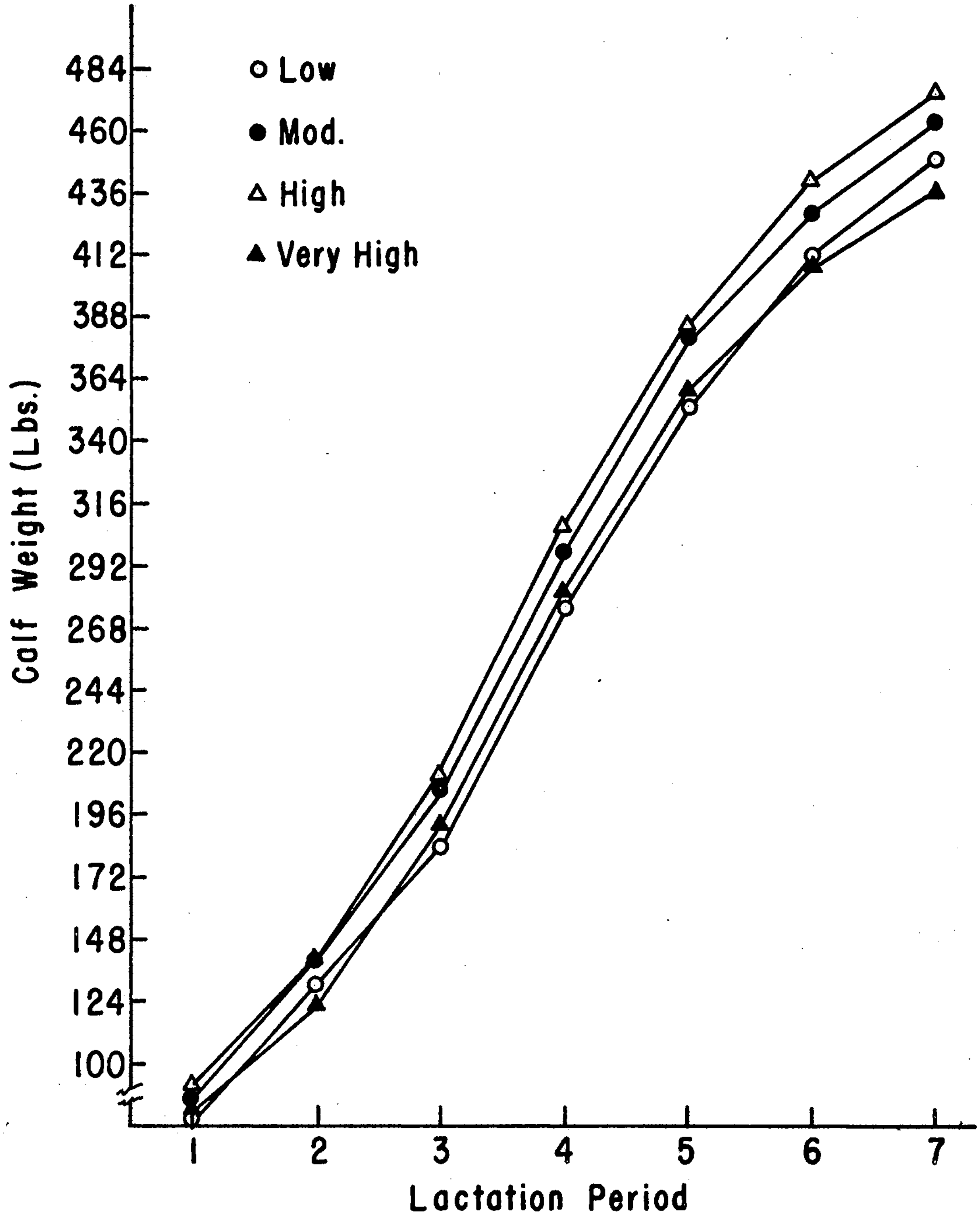

Figure 13. Least Squares Means for Calf Weight in the 1962 Calf Crop From Cows Fed Different Levels of Winter Nutrition

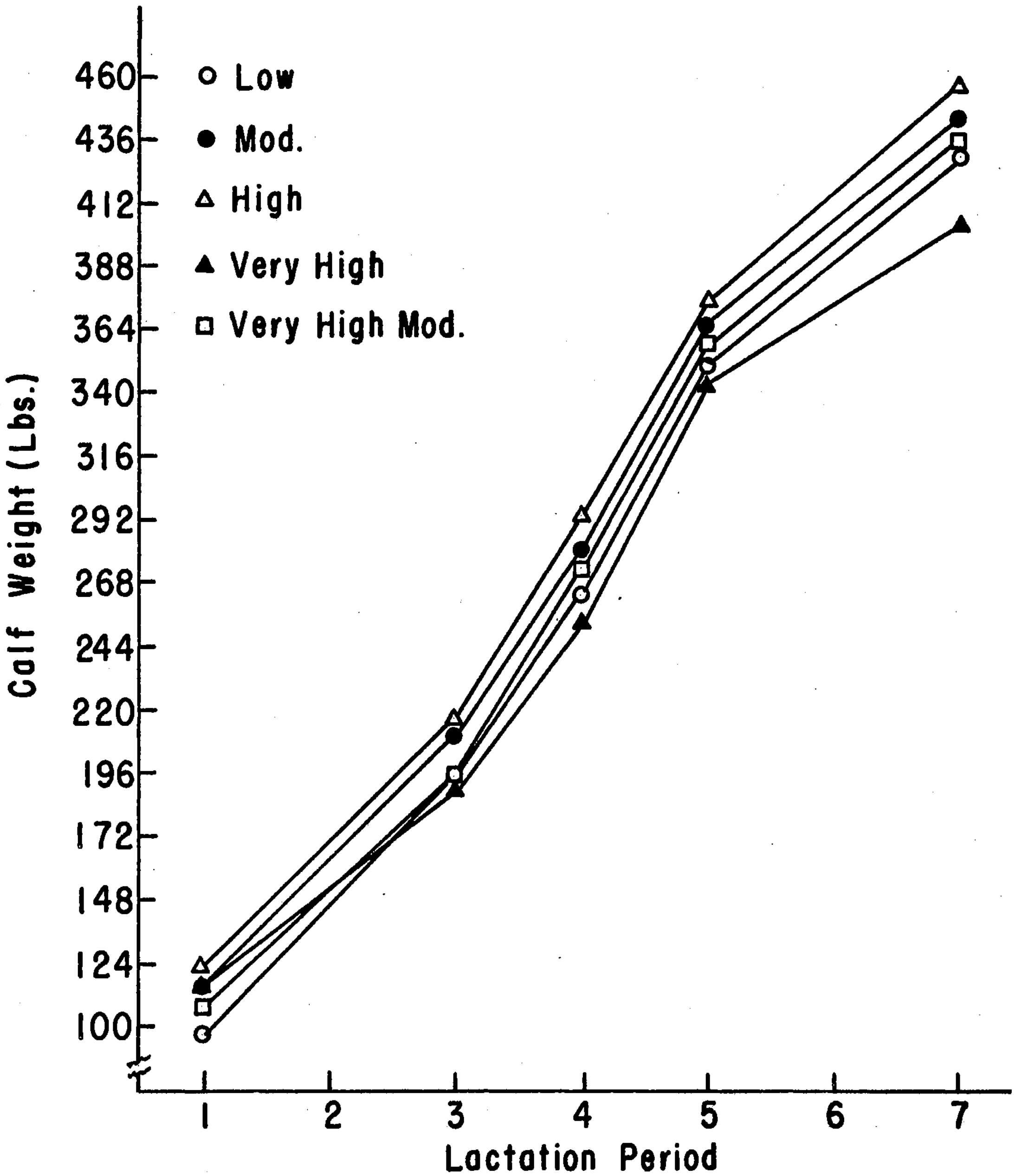

Figure 14. Least Squares Means for Calf Weight in the 1963 Calf Crop From Cows Fed Different Levels of Winter Nutrition

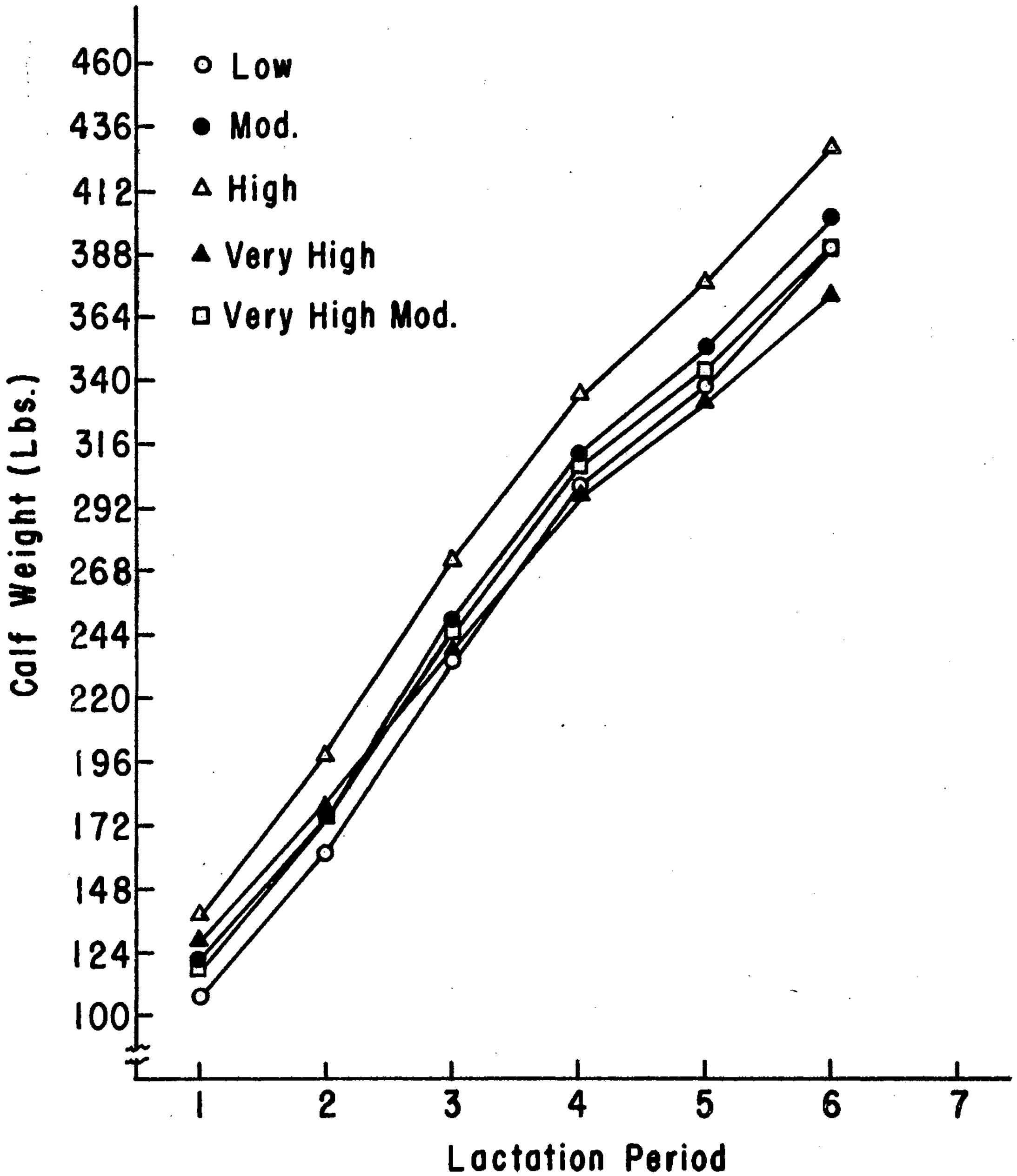

Figure 15. Least Squares Means for Calf Weight in the 1964 Calf Crop From Cows Fed Different Levels of Winter Nutrition

crops are illustrated in Figures 16 and 17, respectively. Weights of calves in lactation period seven were 481, 475, 510, 480 and 461 lb. in 1965, and 449, 450, 456, 441 and 434 lb. in 1966 for Low, Moderate, High, Very High and Very High Moderate calves, respectively. Milk production curves for these two years were somewhat erratic (Figures 8 and 9); however, heavier milkers tended to raise heavier calves. The decline in growth rate of the Very High calves in 1966 was associated with a low level of milk production by the Very High level cows.

The mean calf weights in lactation period seven in 1967 (Figure 18) were 444, 453, 468, 430 and 446 lb. for Low, Moderate, High, Very High and Very High Moderate groups, respectively. The overall weight differences were 28 and 38 lb. in periods one and seven, respectively. Therefore, the increase in weight difference was only 10 lb., indicating similar rates of gain for all calves. Calves from Very High and Low level cows reversed positions in rank; therefore, Low level calves tended to gain faster and Very High level calves tended to gain slower than the other groups. The calves from the Very High Moderate group were 14 lb. heavier than Low level calves at period one; and this weight advantage was not eliminated until period seven, even though the Low level cows produced more milk than the Very High Moderate level cows at all seven estimates.

A study of the least squares means for calf weights revealed information which was not readily apparent in observing the least squares constants. Advantages in calf weight generally paralleled advantages in milk production of the dam; however, in two specific cases, Very High Moderate calves maintained a weight advantage over Low calves even though the Low level cows produced more milk than the Very High Moderate

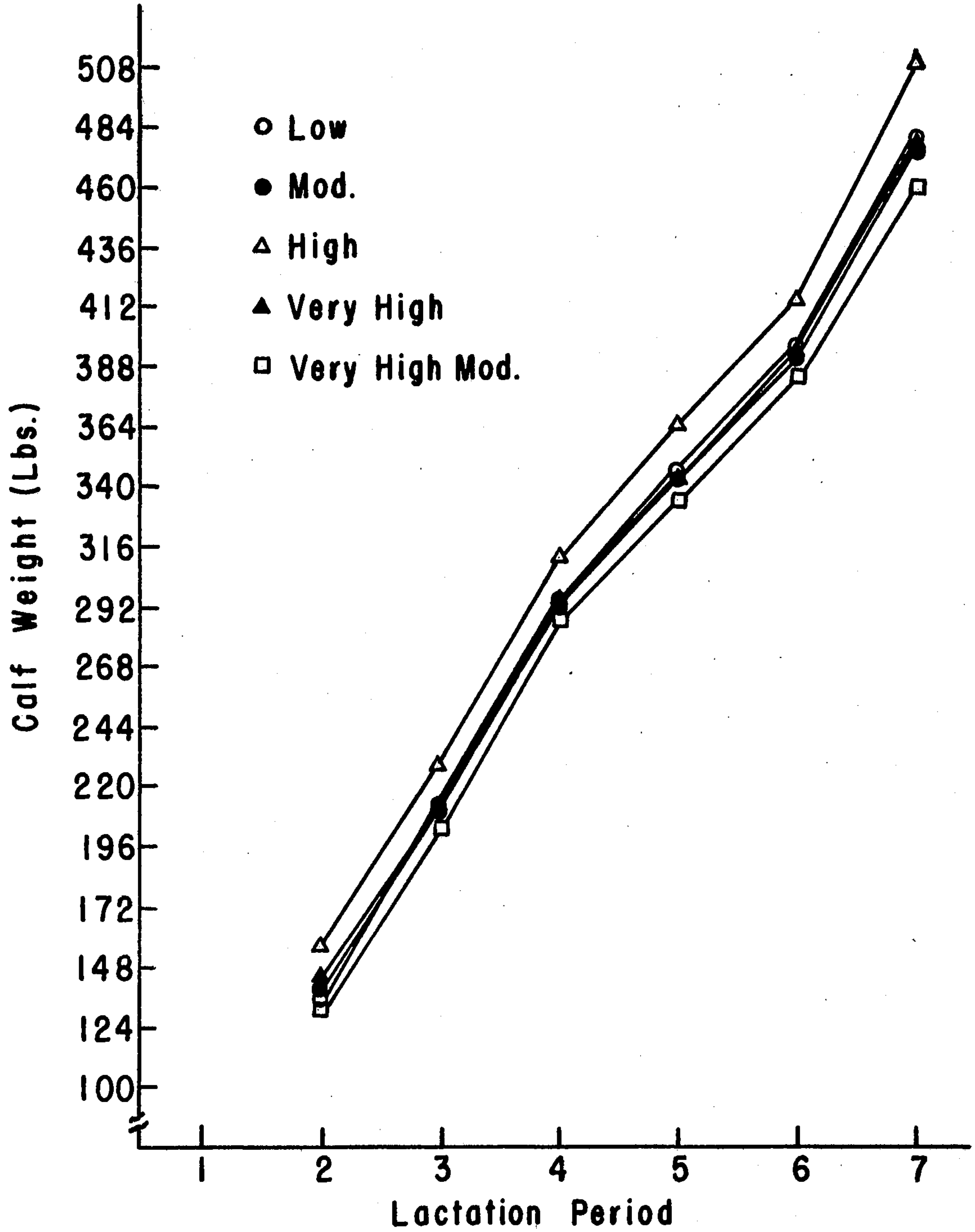

Figure 16. Least Squares Means for Calf Weight in the 1965 Calf Crop From Cows Fed Different Levels of Winter Nutrition

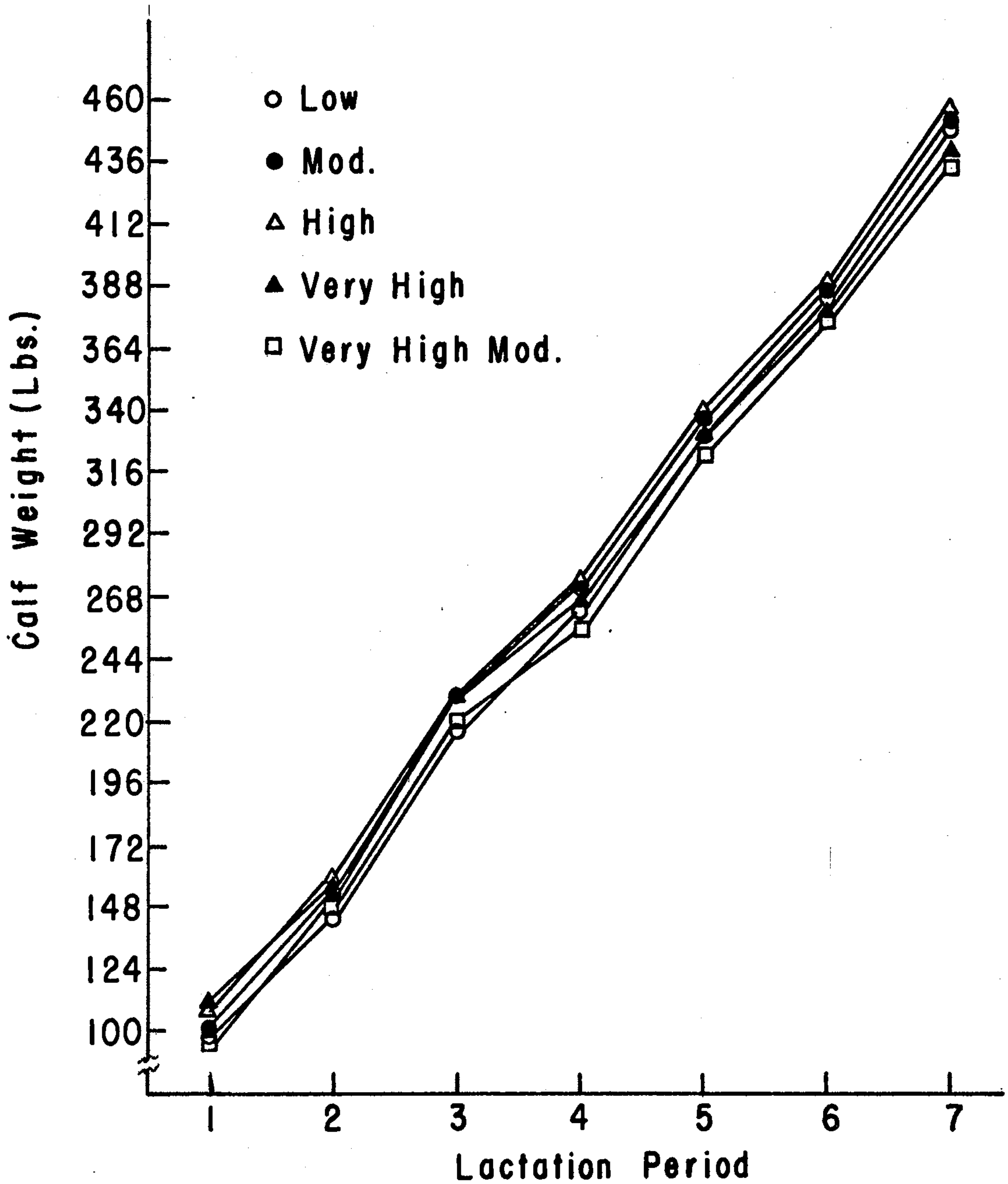

Figure 17. Least Squares Means for Calf Weight in the 1966 Calf Crop From Cows Fed Different Levels of Winter Nutrition

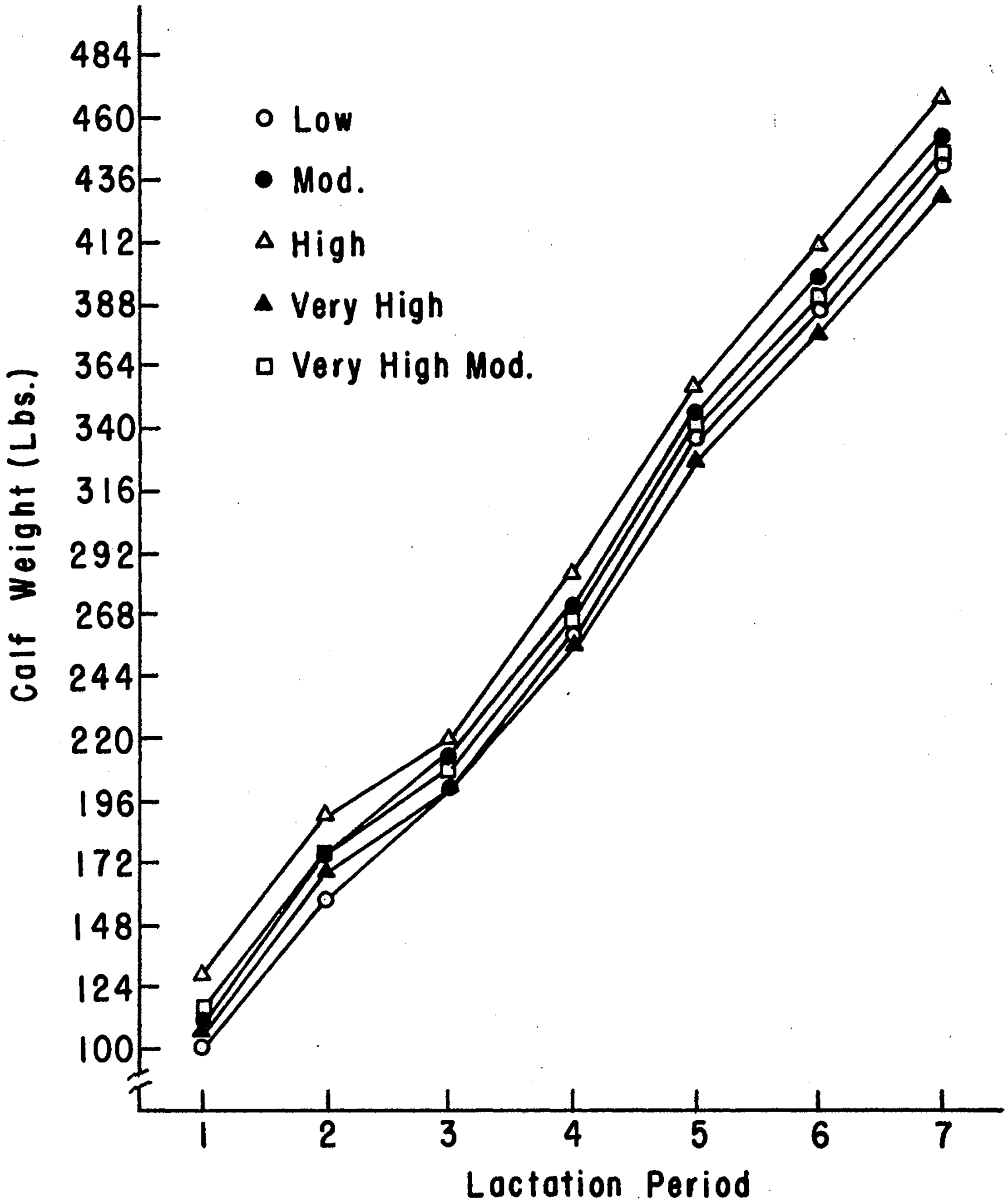

Figure 18. Least Squares Means for Calf Weight in the 1967 Calf Crop From Cows Fed Different Levels of Winter Nutrition

cows. Weight advantages which were established by the time the first weighing was taken tended to be maintained throughout lactation; and, therefore, rates of gain appeared to be similar for all groups of calves. Deviations from this general observation occurred when calves tended to slow down in growth rate during the latter two periods of lactation. This observation was generally associated with a decline in milk flow of the dam. In other words, calves from cows which maintained milk flow in lactation periods six and seven usually continued to gain at a rate similar to that established earlier in lactation. Thus, persistency may be an important factor in beef cattle in maintaining growth rate of the calf even though the calf is consuming considerable forage in the latter portion of lactation. From regressions of average daily calf gains on daily milk production of the dam, Neville (1962) concluded that a pound of milk was worth as much toward calf gain during the seventh and eighth months of lactation as it was during the fifth and sixth months. Regression values were larger in the first 60 days of lactation than at any other time. Several workers have reported that correlations between calf gain and milk production of the dam are higher in the first two months of lactation and decrease as lactation progresses (Gifford, 1953; Howes et al., 1958; Christian et al., 1965). However, Drewry et al. (1959) reported a negative correlation of -.15 between total calf gain from birth through the first month of lactation and estimated daily milk production of the dam.

Since the growth rates of the calves tended to be similar, calves from poor milkers possibly made more efficient utilization of the milk consumed and/or consumed more forage than calves on the higher producing cows. Howes et al. (1958) concluded that from the beginning of the third month of lactation to weaning, beef calves received much of their nutrient supply from grass. Drewry et al. (1959) observed that calves suckling higher producing dams made the least gain from a given volume of milk. Neville (1962) reported that as nutritional treatments (winter supplement and pasture) improved, additional milk was required to produce a pound of calf gain at either 4 or 8 months of age.

Milk samples were not chemically analyzed; therefore, milk composition may have been a factor in the calf growth and milk production relationships observed in this study.

Calf Birth Date, Sex-Corrected Birth Weight, Age- and Sex-Corrected Weaning Weight and Average Daily Gain as Affected by Treatment of Dam

Due to the confounding of age of dam and calendar year effect with calf crop, there is a certain amount of bias if comparisons are made across calf crops; however, the degree of bias in unknown. Levels of significance of treatment effects on calving date, sex-corrected birth weight, age- and sex-corrected weaning weight and average daily gain from birth to weaning are presented in Table XXV. This information will be referred to in the discussion of each variable. No significant group x treatment interactions were obtained in any of the analyses of variance. Group (females started in 1957 or 1958) effects were significant in only five of the analyses, and the differences will be noted in the discussion.

TABLE XXV

LEVELS OF SIGNIFICANCE OF TREATMENT EFFECTS OF CALF BIRTH DATE, BIRTH WEIGHT, WEANING WEIGHT AND AVERAGE DAILY GAIN IN CALF CROPS ONE THROUGH NINE

Variable	Birth Date	Birth Weight	Weaning Weight	Average Daily Gain
Calf Crop				
1	$P < .01$	$P < .001$	$P < .001$	$P < .005$
2	$P < .025$	$P < .025$	$P < .01$	$P < .05$
3	$P < .025$	$P < .025$	NS[a]	NS
4	$P < .025$	NS	NS	NS
5	NS	NS	$P < .025$	$P < .05$
6	NS	NS	$P < .025$	$P < .025$
7	NS	NS	NS	NS
8	NS	NS	NS	NS
9	NS	$P < .05$	NS	NS

[a]NS = nonsignificant ($P > .05$).

Birth Date

The average calving dates for cows fed different levels of winter nutrition are illustrated graphically in Figure 19 and numerically in Appendix Table LI.

Figure 19 indicates that the differences between the earliest and the latest calving date were 18, 30, 20, 17 and 13 days for the first through the fifth calf crops, respectively. Treatment means were significantly ($P<.05$) different in the first through the fourth calf crops. It is evident that the higher levels of nutrition resulted in earlier calving dates in this time frame. In the first calf crop, Low level cows calved 6 days later than the Moderate cows, which calved 12 days later than the Very High cows. A delay in estrus and/or an increase in the number of services per conception may have brought about the differences. Sorenson *et al*. (1954), Reid *et al*. (1957a) and Crichton *et al*. (1959) reported a delay in first heat due to a low level of nutrition. Since the same cows were maintained on treatment from year to year, cows which calved late at first calving would be expected to calve late at second calving, regardless of treatment effect. The range in difference between treatments was greater at the second calving (30 days) as compared to the first (18 days); therefore, some factor other than late first parturition was involved. It appears that the Low level cows required a longer time to recover from first parturition and return to a normal estrous cycle, and/or they required more services per conception for the second calf crop. Turman *et al*. (1965), using parturition data from this study, calculated post-partum interval from first calving to conception and found the average values to be 95, 86 and 74 days for heifers on Low, Moderate and High levels of winter nutrition,

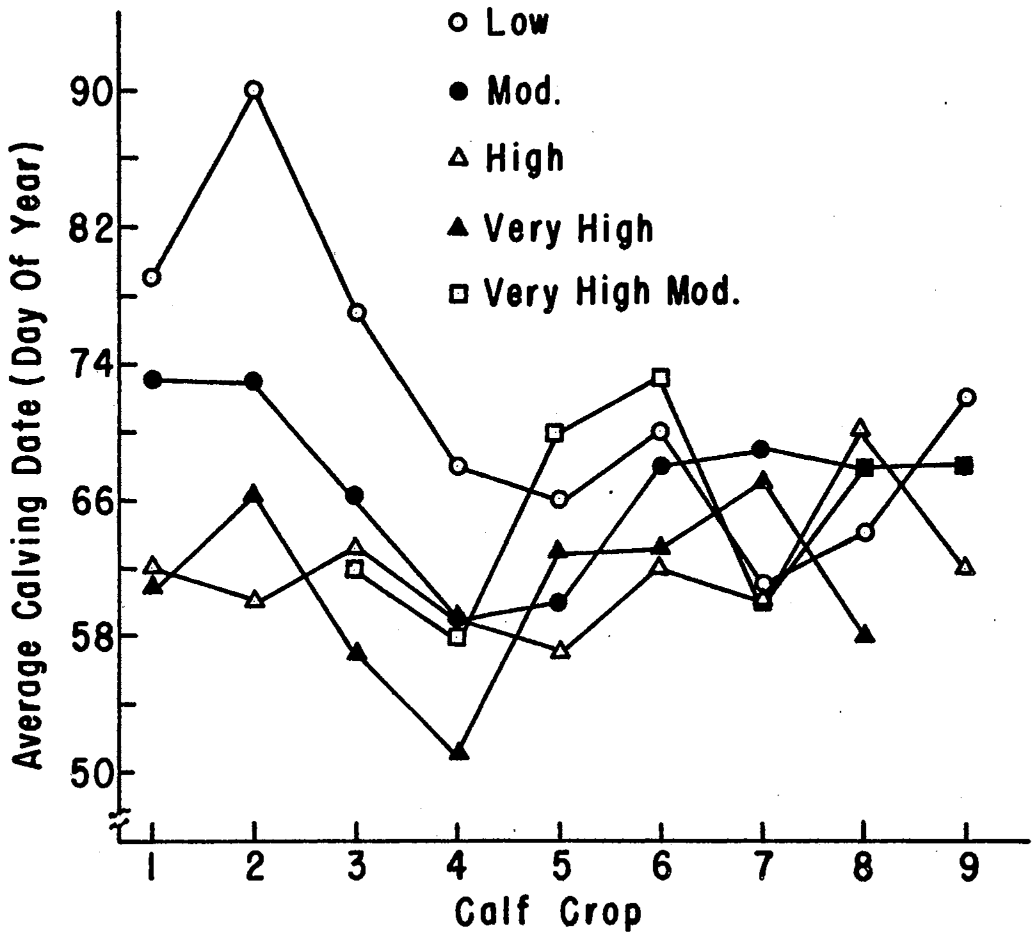

Figure 19. Average Calving Date for Cows Fed Different Levels of Winter Nutrition

respectively. Several other workers have observed similar effects of a low plane of nutrition on the interval from calving to first estrus (Wiltbank et al., 1962; Pinney, 1962; Dunn et al., 1964; Clanton and Zimmerman, 1970).

Since the differences in calving date between the Low level cows and the earlier calving cows (Very High and High levels) decreased from the second calf crop to a nonsignificant difference in the fifth crop, it appears that the Low level cows overcame the delaying effect of reduced nutrition as they became older. Possibly, once the nutrient demand for body growth and development had been met, the Low level dam was able to prepare herself for pregnancy more rapidly.

A significant ($P<.025$) group difference was observed in calf crop six. This may have been caused by a year effect.

Birth Weight

Treatment of the dam also had a significant effect on sex-corrected birth weight of the calves (Figure 20 and Appendix Table LII). Statistically significant treatment differences were observed in calf crops one ($P<.001$), two ($P<.025$), three ($P<.025$) and nine ($P<.05$). A significant ($P<.005$) group effect was noted only in calf crop one. The average sex-corrected birth weights in the first calf crop were 57.9, 66.9, 71.3 and 68.1 lb. for Low, Moderate, High and Very High treatment groups, respectively. The difference between the heaviest calves and the lightest calves was 13.4 lb., and this difference was 7.8, 8.6 and 9.5 lb. in calf crops, two, three and four, respectively. When one group of the Very High level cows was switched to the Moderate level of nutrition, birth weights of the calves tended to parallel birth weights

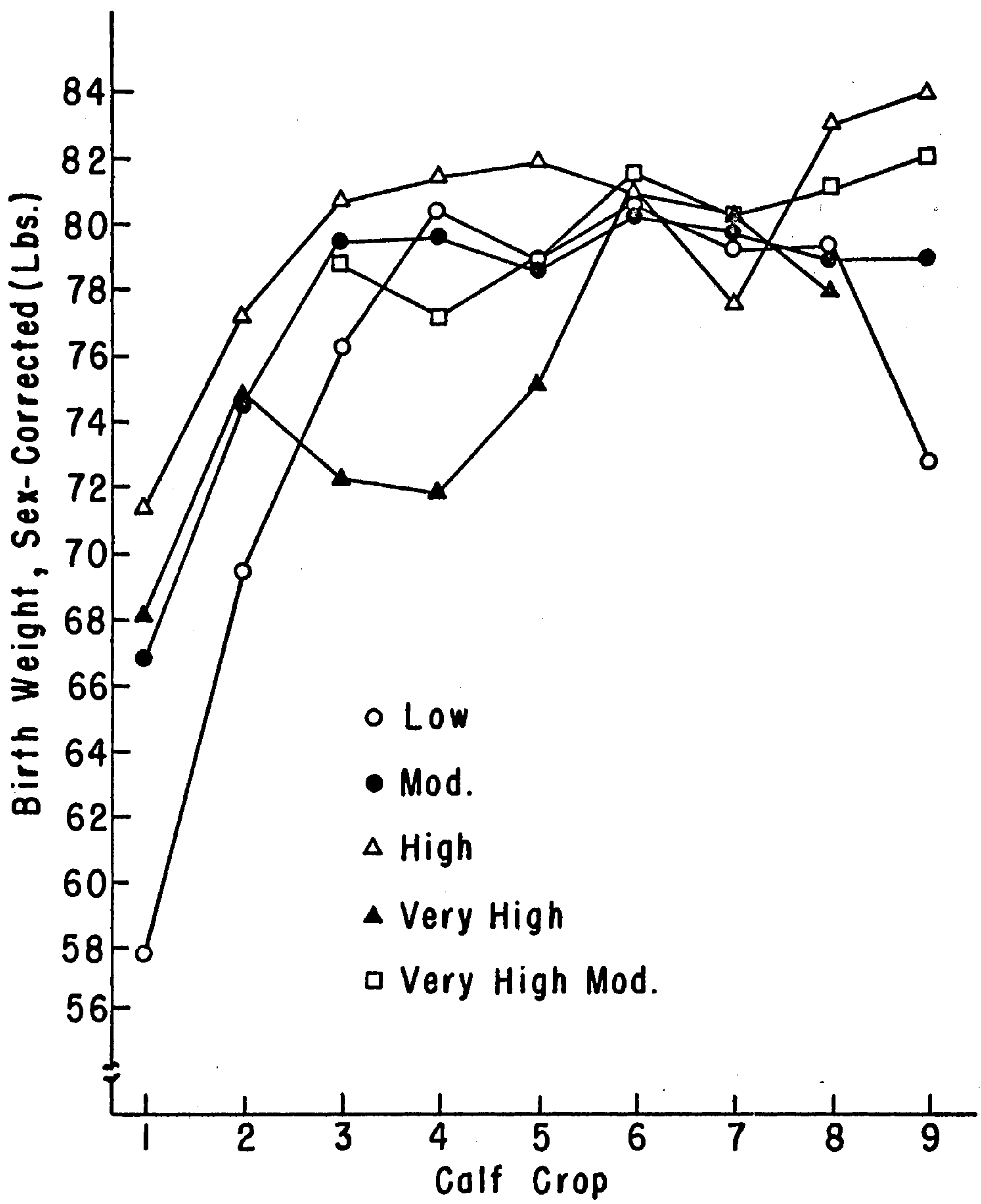

Figure 20. Sex-Corrected Birth Weight of Calves From Cows Fed Different Levels of Winter Nutrition

of calves from the Moderate cows, while birth weights of calves from the cows remaining on the Very High level were much lower until the sixth calf crop. The Very High level cows were extremely fat, and there is a possibility that internal fat deposits restricted the environment of the fetus and, thereby resulted in reduced birth weights.

Without data for subsequent calf crops, it is difficult to draw meaningful conclusions from the significant difference in calf birth weight in calf crop nine. Birth weights were 72.8, 79.0, 84.0 and 82.1 lb. for Low, Moderate, High and Very High Moderate cows, respectively. It may be that at approximately 11 years of age and under the conditions in which these cows were maintained, the nutrient requirement for body tissue repair becomes so great that body functions for maintenance are conducted at expense of the fetus.

Joubert (1954), Reid et al. (1957a), Pinney (1962) and Hight (1966) observed that low planes of nutrition for the dam resulted in lighter calves at birth. Birth weight differences of 12 to 14 lb. between calves from cows on low and high levels of nutrition have been reported (Renbarger et al., 1964; Hight, 1966). Varying observations have been reported on the effect of age of dam on birth weight of the calf. Marlowe (1962) reported that there was an increase in calf birth weight of 1 2/3 lb. for each year increase in age of the beef dam up to 7 years. Koonce and Dillard (1967), in a study with cows ranging in age from 3 to 11 years, reported that weights of calves from 11-year-old cows were 1.12 kg more than the least squares mean weight.

Weaning Weight

The average age- and sex-corrected weaning weights of calves from cows fed the different levels of winter nutrition are presented in Appendix Table LIII. The data are shown graphically in Figure 21. Analyses of variance revealed significant treatment differences in calf crops one ($P<.001$), two ($P<.01$), five ($P<.025$) and six ($P<.025$). A significant ($P<.025$) difference between groups of cows occurred in calf crop seven.

In the first calf crop, corrected weaning weights were 338.5, 397.0, 409.7 and 394.4 lb. for calves from the Low, Moderate, High and Very High cows, respectively. The overall difference between heaviest and lightest groups was 71.2 lb. and this was reduced to 59.7 lb. in calf crop two, 33.3 lb. in calf crop three and 38.1 lb. in calf crop four. Weight difference between High level and Low level calves in calf crop four was 9.3 lb. As noted previously with respect to other criteria, Low level cows required approximately 4 to 5 years to overcome the adverse effects of the reduced winter nutrition. This trend again was evident in calf weaning weight as weaning weights of calves from the Low level cows increased rapidly through the fourth calf crop.

It is interesting to note that even though the Very High Moderate cows were maintained with the Moderate cows after the second calf crop, weaning weights of their calves were always less than those of calves from the Moderate cows. Weaning weights of calves from the Very High level cows were slightly lower than those for the Very High Moderate group except for calf crops six and seven when the Very High calves were considerably heavier than the Very High Moderate calves.

The weaning weights for calf crops five and six were 476.6, 476.6; 475.6, 487.1; 503.3, 516.1; 434.1, 484.6; and 472.2, 465.3 lb., respectively for Low, Moderate, High, Very High and Very High Moderate

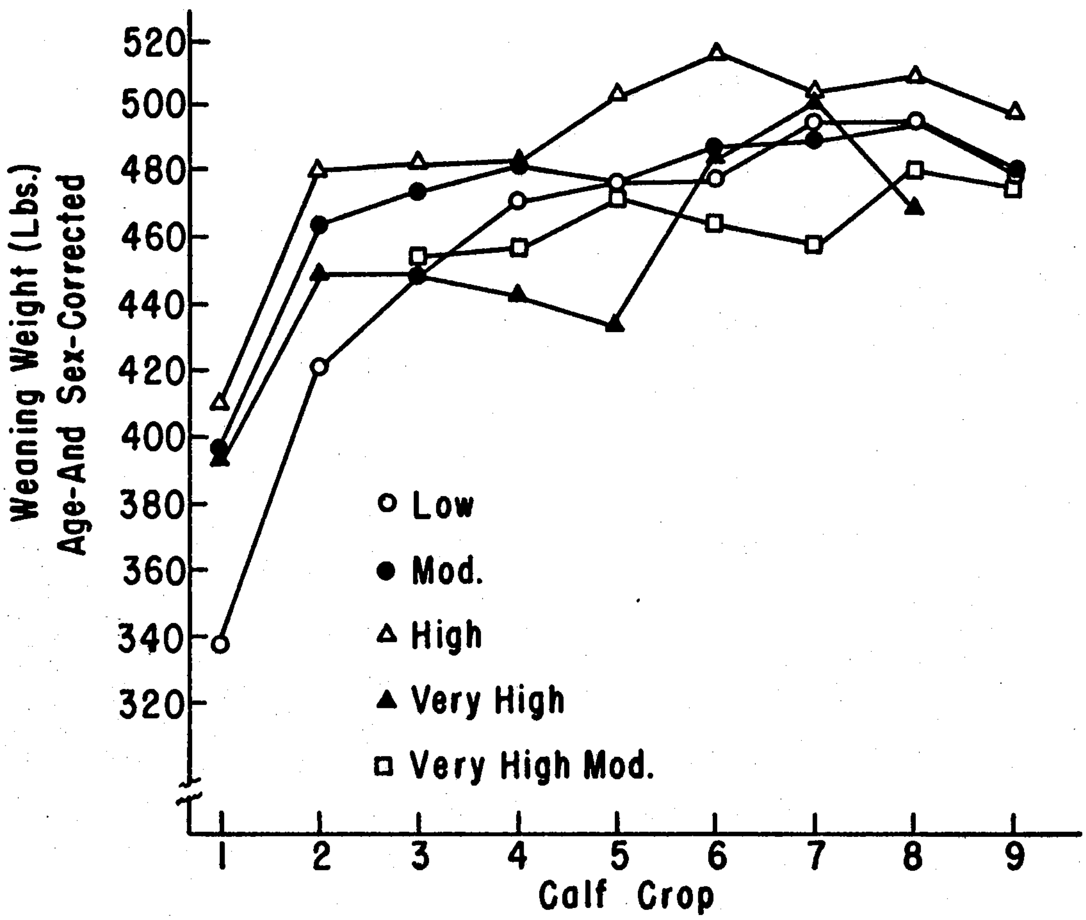

Figure 21. Age- and Sex-Corrected Weaning Weight of Calves From Cows Fed Different Levels of Winter Nutrition

level cows. After the fourth calf crop, the year to year variation was probably influenced greatly by weather conditions during the winter and the grazing season; however, overall average weaning weight appeared to increase slightly up to the seventh calf crop. Several workers have reported that maximum calf weaning weights were obtained with beef cows in the range of 6 to 10 years of age (Marlowe and Gaines, 1958; Pahnish et al., 1961; Godley et al. , 1966).

The trends in weaning weight were similar to those discussed with regard to milk production and calf weights. The significant treatment differences found in calf crops five and six after two calf crops without significant differences probably indicate that existing winter conditions and grazing conditions have a great influence on the response of older beef cows to different levels of wintering. Joubert (1954), Dunn et al. (1965) and Hight (1966) observed that a low precalving plane of nutrition for the dam significantly decreased the weaning weight of the calf. Knox and Watkins (1958) reported that feeding supplemental protein or energy to range beef cows prior to calving and through lactation improved the weaning weights of young cows, but that it did not improve production of cows over 5 years of age. Marion and Hammack (1969) observed that winter energy levels ranging from 11.8 to 20.7 therms per day for cows in drylot and supplemental energy ranging from 1.6 to 7.1 therms for cows on pasture had no significant effects on calf weaning weights.

Average Daily Gain

As would be expected, the average daily gains of calves from cows receiving the different levels of winter nutrition (Figure 22) followed

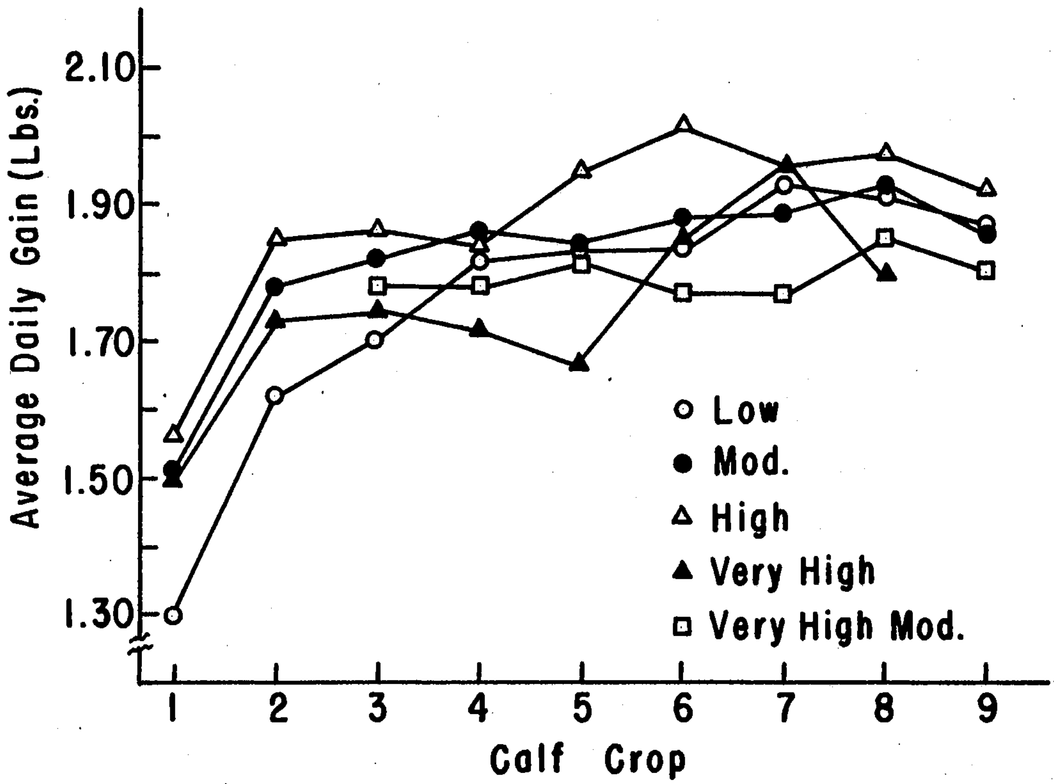

Figure 22. Average Daily Gain of Calves From Cows Fed Different Levels of Winter Nutrition

the pattern observed for weaning weights. Treatment means are presented in Appendix Table LIV. Statistically significant treatment differences were present in calf crops one ($P < .005$), two ($P < .05$), five ($P < .05$) and six ($P < .025$). A significant ($P < .01$) difference between cow groups was observed in calf crop seven.

Treatment means (1.30, 1.51, 1.56 and 1.50 lb. for Low, Moderate, High and Very High calves, respectively) indicate that calf average daily gain was considerably lower for the Low calves than for calves from the other three treatment groups in calf crop one. The overall difference was 0.26 lb. per day. These gains compare favorably with those reported by Renbarger et al. (1964), but they are higher than the gains observed by Howes et al. (1958). In calf crop two the relative rank remained the same with the values being 1.62, 1.78, 1.85 and 1.73 lb. with an overall difference of 0.23 lb. per day. The data indicated a rapid increase in average daily gain from calf crop one to two; however, the relative differences remained approximately the same. The respective values for Low, Moderate, High, Very High and Very High Moderate calves in calf crop three were 1.70, 1.82, 1.86, 1.74 and 1.78 lb. per day with a range in difference of 0.16 lb. per day. Values for calves from the same cows in calf crop four were 1.82, 1.86, 1.84, 1.72 and 1.78 lb. per day, respectively, and the overall difference was 0.14 lb. per day. These gains during the latter calf crops are similar to the calf gain reported by Melton et al. (1967a).

The average daily gains for calves from the Low level cows started at a low level in calf crop one and then increased very rapidly through calf crop four. Values for the other treatment groups showed a rapid increase in calf crop two, a slight increase in calf crop three and a tendency to level off in calf crop four. In comparing calf crop five with four, the average daily gain value for calves from the High level cows increased rapidly, the value for calves from Very High cows decreased, and values for the other three groups remained about the same. This resulted in an overall difference of 0.28 lb. per day between fastest (High) and slowest (Very High) gaining groups. In the sixth calf crop, values for the High and the Very High treatment groups were considerably higher than they were in calf crop five. There appeared to be a general trend for a slight increase in calf average daily gain from calf crop three through eight. In data from beef cows 2 to 10 years of age, Melton et al. (1967a) also observed an increase in calf gain with an increase in age of dam. Marlowe et al. (1964) observed that calf gains from birth to weaning increased with cow's age from 2 to 6 years, remained approximately the same for 6 to 11 years and declined slightly thereafter.

The average daily gain of a beef calf is influenced by genetic potential and nutrient consumption. Since an attempt was made to minimize genetic and pasture differences, average daily gain of the calf should be a good indicator of the dam's milk production. The observation that the average daily gain of calves from the Low level cows reached a plateau at a later calf crop than calves from the other treatment groups may be a result of restricted mammary development as reported by Swanson and Hinton (1964). This delay in attaining production of a level similar to that of the High and the Moderate level cows is consistent with the results in the criteria discussed previously.

Cow Body Weights and Body Measurements

Due to the confounding of age of dam and calendar year effects with year of treatment, there is a certain amount of bias if comparisons are made across years of treatment; however, the degree of bias is unknown. The levels of statistical significance of treatment effects on body weight and body measurements of cows fed different levels of winter nutrition are presented in Table XXVI. Treatment means for body weight, width at the pins, width at the hooks, width at the loin, circumference of the heart girth, height at the withers, depth of chest, distance from chest floor to ground and length of body are presented numerically in Appendix Tables LV, LVI, LVII, LVIII, LIX, LX, LXI, LXII and LXIII, respectively, and graphically in Figures 23 through 28 and 30 through 32, respectively. The figures indicate that considerable variation in body measurements occurred from season to season and from year to year. The fact that lower values were obtained in the spring than in the previous fall indicates that the measurements were influenced to a great extent by external body fat. When the Very High level cows were switched to the Moderate level of nutrition, body measurement values decreased and became almost equal to the values for the Moderate cows while values for the cows remaining on the Very High level were considerably greater. Also, the cows which remained on the Very High level were changed from a self-fed regime in the seventh winter to a specified quantity of supplemental feed per day. At the time this change was made, body weights and measurements of these cows started a continual decline. With all evidence pointing toward skeletal measurements being confounded with body condition, it was concluded that only trends in growth patterns should be discussed, even though statistically significant treatment

TABLE XXVI

LEVELS OF SIGNIFICANCE OF TREATMENT EFFECTS ON BODY WEIGHTS AND BODY MEASUREMENTS OF COWS FED DIFFERENT LEVELS OF WINTER NUTRITION

Variable		Body Weight	Width at Pins	Width at Hooks	Width at Loin	Circumference of Heart Girth	Height at Withers	Depth of Chest	Chest to Ground	Length of Body
Year of Treatment	Season[a]									
1	F	NS[b]	NS	NS	NS	NS	NS	NS	NS	NS
2	S	$P<.001$	$P<.001$	$P<.001$	$P<.001$	$P<.001$	$P<.001$	$P<.001$	$P<.005$	$P<.005$
	F	$P<.005$	$P<.001$	$P<.001$	$P<.001$	$P<.001$	$P<.025$	$P<.001$	NS	$P<.025$
3	S	$P<.001$	$P<.001$	$P<.001$	$P<.001$	$P<.001$	$P<.005$	$P<.001$	$P<.001$	$P<.001$
	F	$P<.001$	$P<.005$	$P<.001$	$P<.001$	$P<.001$	$P<.005$	$P<.001$	NS	$P<.005$
4	S	$P<.001$	$P<.001$	$P<.001$	$P<.001$	$P<.001$	$P<.005$	$P<.001$	$P<.001$	$P<.001$
	F	$P<.001$	$P<.005$	$P<.005$	$P<.005$	$P<.005$	NS	$P<.005$	NS	$P<.005$
5	S	$P<.001$	$P<.005$	$P<.005$	$P<.005$	$P<.005$	$P<.05$	$P<.005$	NS	$P<.025$
	F	$P<.005$	NS	$P<.005$	$P<.001$	$P<.001$	$P<.05$	$P<.005$	$P<.05$	$P<.005$
6	S	$P<.001$								
	F	$P<.001$	$P<.005$	$P<.05$	$P<.01$	$P<.005$	NS	$P<.005$	$P<.005$	NS
7	S	$P<.001$	$P<.005$	$P<.001$	$P<.001$	$P<.001$	$P<.005$	$P<.005$	$P<.005$	$P<.005$
	F	$P<.001$	$P<.005$	$P<.005$	$P<.005$	$P<.005$	NS	$P<.005$	NS	$P<.05$
8	S	$P<.001$	$P<.05$	$P<.005$	$P<.005$	$P<.001$	NS	$P<.005$	$P<.005$	$P<.05$
	F	$P<.005$	NS	$P<.05$	$P<.005$	P .005	NS	$P<.005$	NS	NS
9	S	$P<.001$	$P<.05$	$P<.01$	$P<.01$	$P<.005$	NS	$P<.005$	$P<.05$	NS
	F	NS	NS	NS	NS	NS	NS	NS	$P<.05$	NS
10	S	$P<.001$	$P<.01$	$P<.05$	$P<.005$	$P<.005$	NS	NS	NS	NS
	F	NS	NS	NS	NS	NS	NS	NS	NS	NS
11	S	$P<.025$	NS	NS	$P<.05$	$P<.005$	NS	$P<.025$	NS	NS
	F	NS	NS	NS	NS	NS	NS	NS	NS	NS

[a] F = fall, S = spring.

[b] NS = nonsignificant ($P>.05$).

differences existed at almost all of the measurings up to the ninth year of treatment. Since the body weights and body measurements of the Very High level cows decreased to values similar to those observed for cows on the other treatments at the time treatment differences became statistically nonsignificant, significant treatment effects in analyses for earlier years were probably partly due to the extremely large values for the Very High cows.

In order to determine the age at which measurements tended to plateau (maturity), the spring values were selected for observation and discussion. These values were selected since it was observed that they were influenced to a lesser degree by body fat than the fall measurements. The Very High level cows gained weight during the winter and lost weight in the summer; therefore, their weight and measurement patterns were exactly opposite to those of cows in the other treatment groups. For this reason, values for the Very High level cows will be discussed separately.

Due to data not being available for the spring of the sixth year, it was difficult to estimate the age of maturity for several of the measurements.

Body Weight

Average cow body weights for each treatment within each season within each year of treatment are presented graphically in Figure 23. Even though the original objective was to feed the High level cows so that no weight loss would occur during winter, these cows did lose weight in the second and subsequent winters (Table 11). Differences among body weights of cows receiving the Low, Moderate, High and Very High Moderate

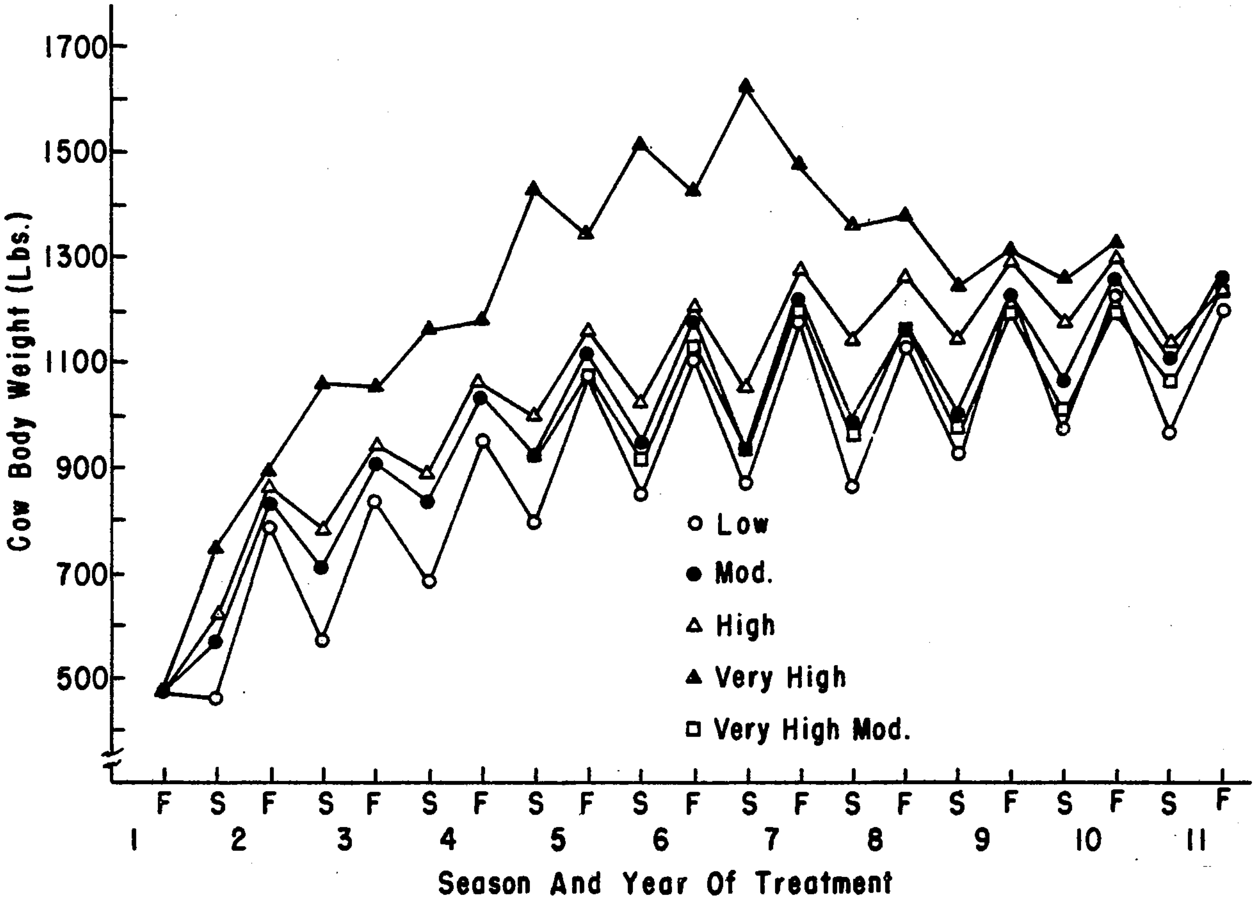

Figure 23. Average Body Weights of Cows Fed Different Levels of Winter Nutrition

levels of winter nutrition were greater in the spring than in the fall. In other words, cows which lost more weight in the winter gained more weight during the summer. This inverse relationship has been observed by numerous workers (Joubert, 1954; Nelson *et al*., 1954; Zimmerman, 1960; Velasco, 1962; Clanton and Zimmerman, 1970). Maximum body weight values for the Very High level cows (1621 lb.) occurred in the spring of the seventh year of treatment (6 years of age). It must be noted that the Very High level cows were changed from an *ad lib*. regime to a limited supplemental winter feed consumption the following winter; therefore, body weights might have increased even further on an *ad lib*. feeding system. Body weights of cows on the other treatments tended to plateau in the fall of the seventh year of treatment (6.5 years of age), even though there was a slight increase up to the fall of the tenth year of treatment. Average body weights in the fall of the seventh year of treatment were 1179, 1223, 1275 and 1195 lb. for Low, Moderate, High and Very High Moderate cows, respectively. The High and the Very High level cows maintained a weight advantage over cows in the other treatment groups throughout the study. Low level cows remained lighter than the Moderate and the Very High Moderate cows until the fall of the ninth year of treatment; however, overall difference among these groups was only 44 lb. in the fall of the seventh year. Pinney (1962) observed that under range conditions, Hereford cows which received a high level of winter nutrition each year attained maximum fall body weight at 7.5 years of age and females receiving low and medium levels of winter supplementation reached maximum body weight at 10.5 years of age. In a study with dairy heifers where nutritional treatment varied until 2 months prior to parturition, Crichton *et al*. (1959) observed that body weights of low plane heifers averaged only 68% as great as body weights of the high plane heifers at 44 weeks of age. However, no significant treatment differences in body weight were observed at 5 years of age (Crichton *et al*., 1960a). Knox and Koger (1945) and Brinks *et al*. (1962) observed that Hereford range cows continued to add weight up to 8 years of age.

Width at the Pins

Values for width at the pins (Figure 24) appeared to plateau in the fall of the fourth year of treatment (3.5 years of age) for the Very High cows (12.99 in.) and in the spring of the fifth year (4 years of age) for the Moderate (11.85 in.), High (12.32 in.) and the Very High Moderate (11.93 in.) cows. Data were not available for the spring of the sixth year, but the graph indicates a plateau point for the Low level cows at that time. Values at 7 years of age compare favorably with those reported by Pinney (1962) for Hereford cattle of the same age.

Width at the Hips

Without body measurement data for the spring of the sixth year, it is difficult to determine the plateau point for width at the hips (Figure 25). Possibly, it occurred in the spring of the sixth year; however, only slight increases were noted in the values after the spring of the fifth year of treatment (4 years of age). Values for the Low, Moderate, High and Very High Moderate cows were 19.37, 20.40, 20.82 and 20.41 in., respectively. The Very High level cows increased in width up to the fall of the seventh year (6.5 years of age). The values at three

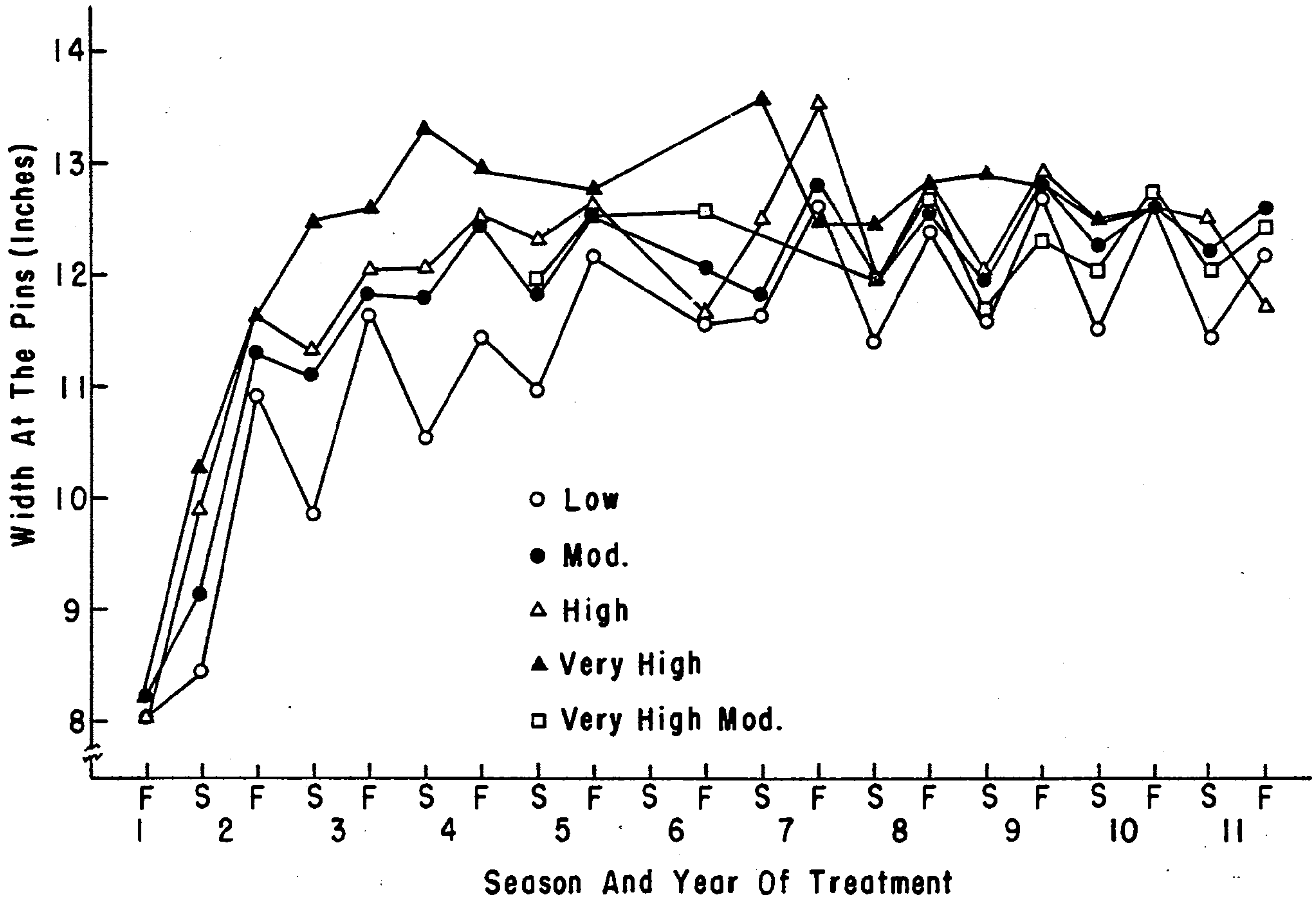

Figure 24. Average Values for Width at the Pins of Cows Fed Different Levels of Winter Nutrition

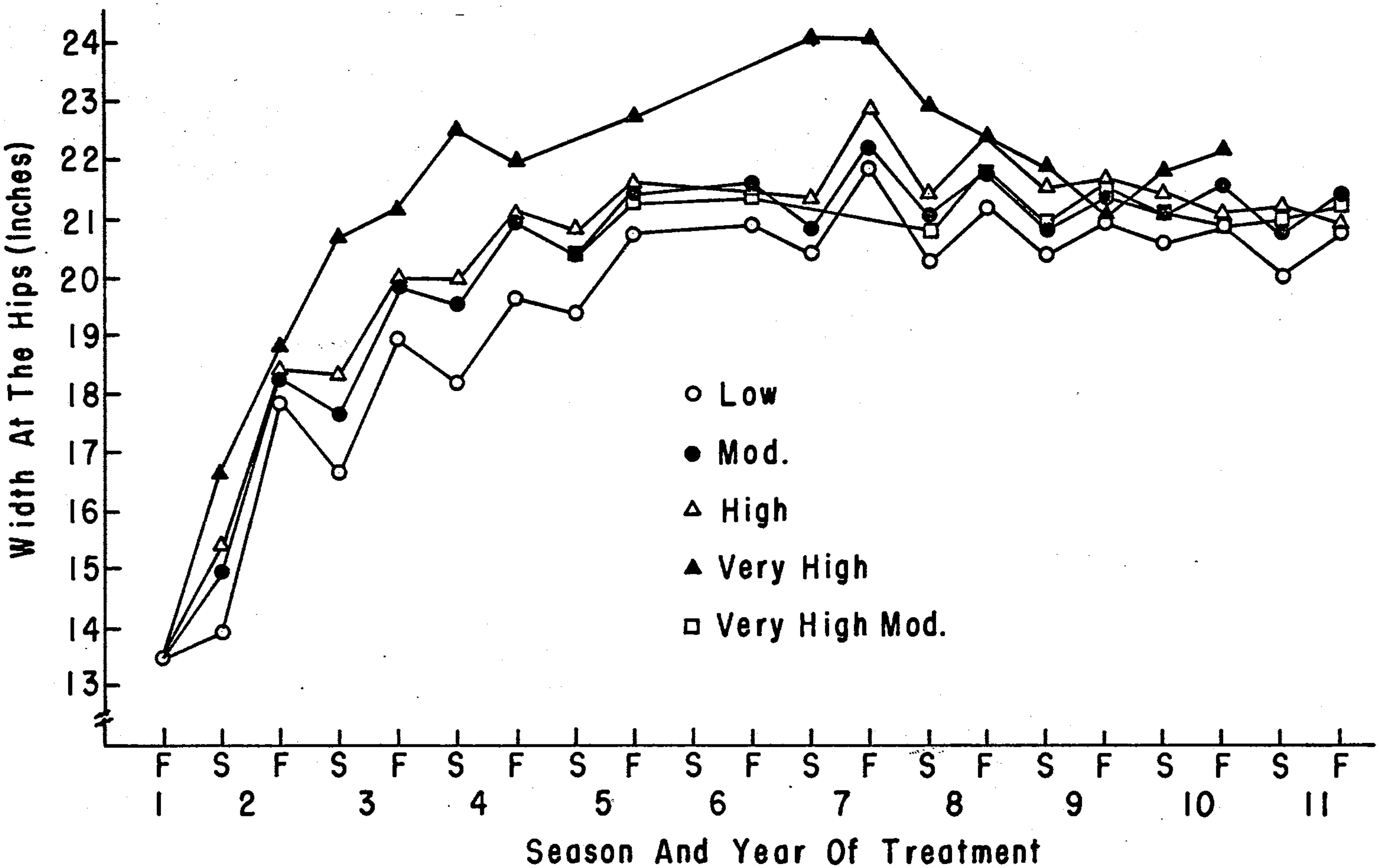

Figure 25. Average Values for Width at the Hips of Cows Fed Different Levels of Winter Nutrition

years of age are higher than those reported by Brown and Franks (1964) for three-year-old Hereford cows; however, the values at 7 years of age are similar to those reported by Pinney (1962). Crichton *et al*. (1960a) observed that there was a slow but continuous growth in width at the hips of dairy cattle up to 9 years of age; however, significant differences due to levels of nutrition were no longer evident after 5 years of age.

Width at the Loin

Figure 26 indicates that very little increase was obtained in width at the loin after the spring of the seventh year of treatment (6 years of age). Values for the Low, Moderate, High and Very High Moderate cows were 13.73, 14.00, 14.60 and 13.30 in. (interpolated), respectively. The value (16.54 in.) for the Very High level cows peaked at the same age.

Circumference of the Heart Girth

The data (Figure 27) reveal that the plateau point for the spring measurement of circumference of the heart girth was again in the seventh year of treatment (6 years of age). Values were 68.55, 70.15, 73.75, 74.5 (interpolated) and 87.65 in., respectively for cows on the Low, Moderate, High, Very High Moderate and Very High levels of wintering. It is interesting to note that this age corresponds to the plateau age for body weight. The data indicate a close relationship between body weight and circumference of the heart girth (Figures 23 and 27).

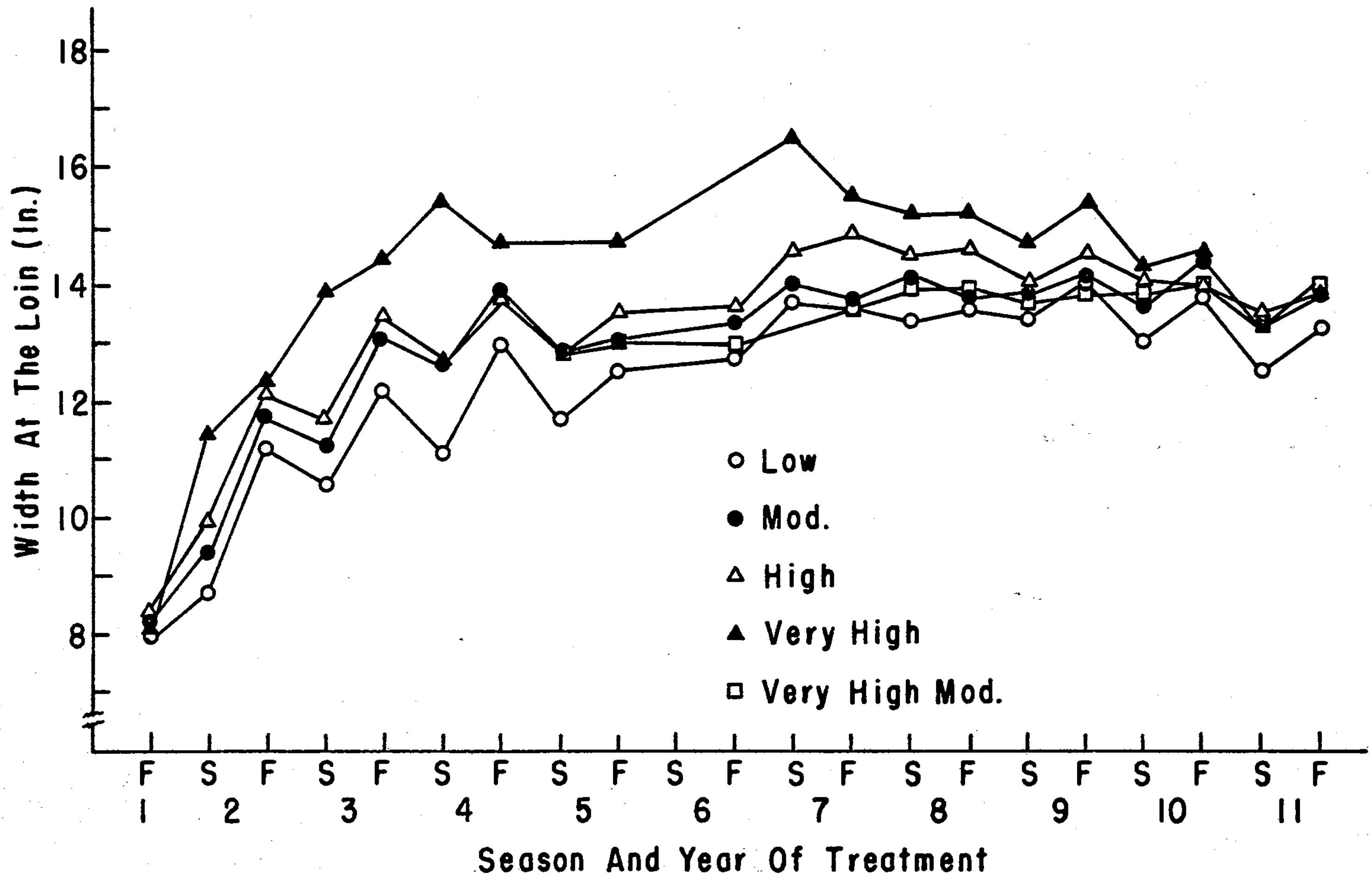

Figure 26. Average Values for Width at the Loin of Cows Fed Different Levels of Winter Nutrition

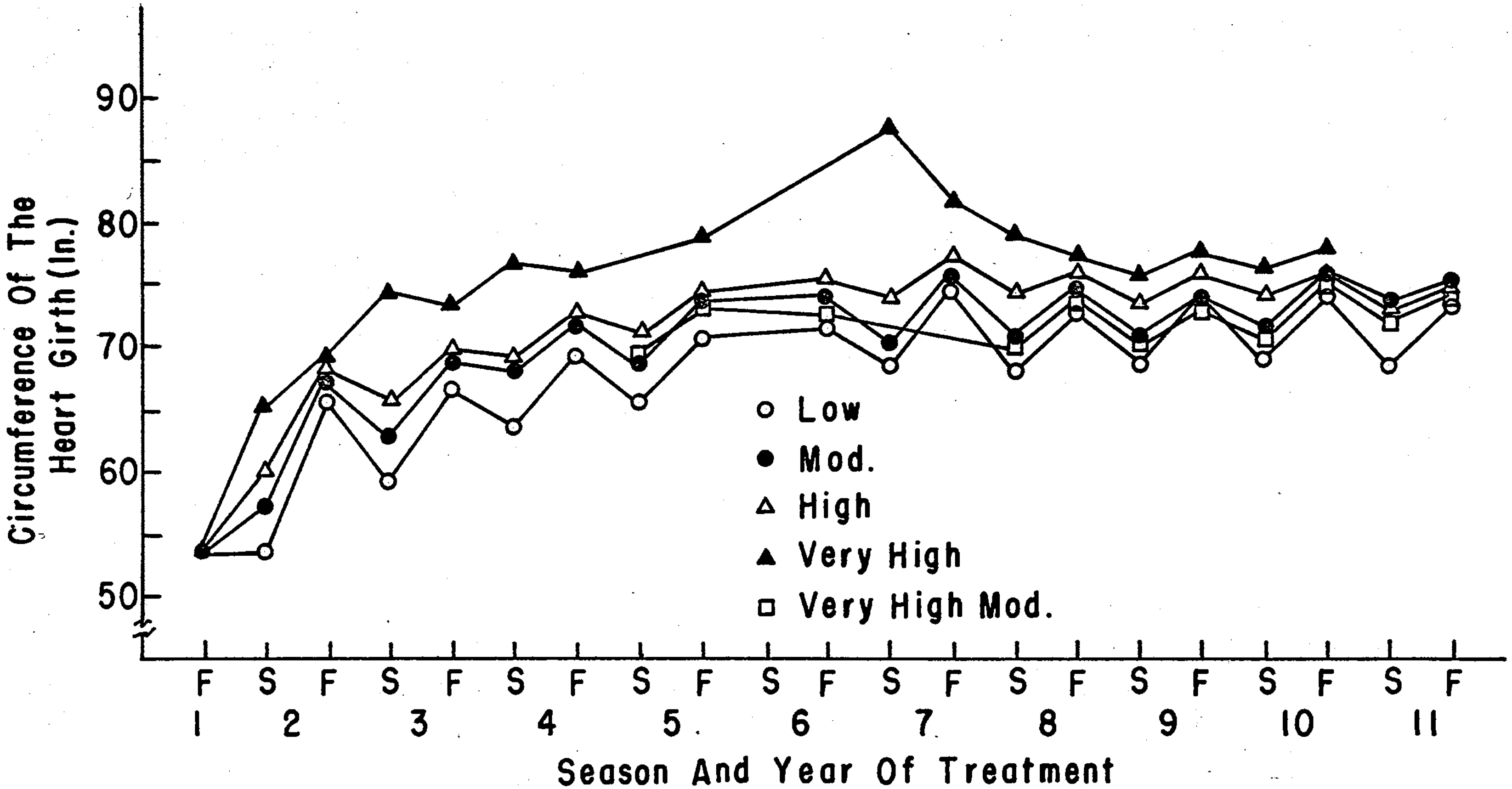

Figure 27. Average Values of Circumference of the Heart Girth of Cows Fed Different Levels of Winter Nutrition

Height at the Withers

In comparison with the other body measurements, there was less season-to-season variation in height at the withers (Figure 28) which may indicate that this measurement was influenced to a lesser degree by body fat. Therefore, it was concluded that height at the withers would more closely represent skeletal development and skeletal size at various ages. The plateau point for height at the withers appeared to be in the spring of the fifth year of treatment (4 years of age). Average values for cows in Low, Moderate, High, Very High Moderate and Very High levels of winter nutrition were 45.69, 46.88, 47.00, 46.86 and 47.10 in. (interpolated), respectively. The value for the Low level group was 1.17 to 1.41 in. below values for the other treatment groups. This may indicate that the Low level of nutrition delayed maturity in height at the withers. Crichton et al. (1960a) reported that dairy heifers which received a high plane of nutrition attained maturity in height at the withers 8 to 9 months earlier than females which received a low plane of nutrition prior to first parturition. They observed that treatment differences in this measurement disappeared as early as 132 weeks of age. In beef cattle, Pinney (1962) reported that significant treatment differences were apparent in wither height at 3.5 years of age, but not at 5 years. Crichton et al. (1960a) concluded that growth in wither height ceased at 6 years of age.

To better illustrate the relationship between skeletal development and body weight, the averages of the values of height at the withers and the averages of the body weights of cows on the Low, Moderate, High and Very High Moderate treatments are plotted in Figure 29. The values indicate that there was a very rapid increase in height at the withers

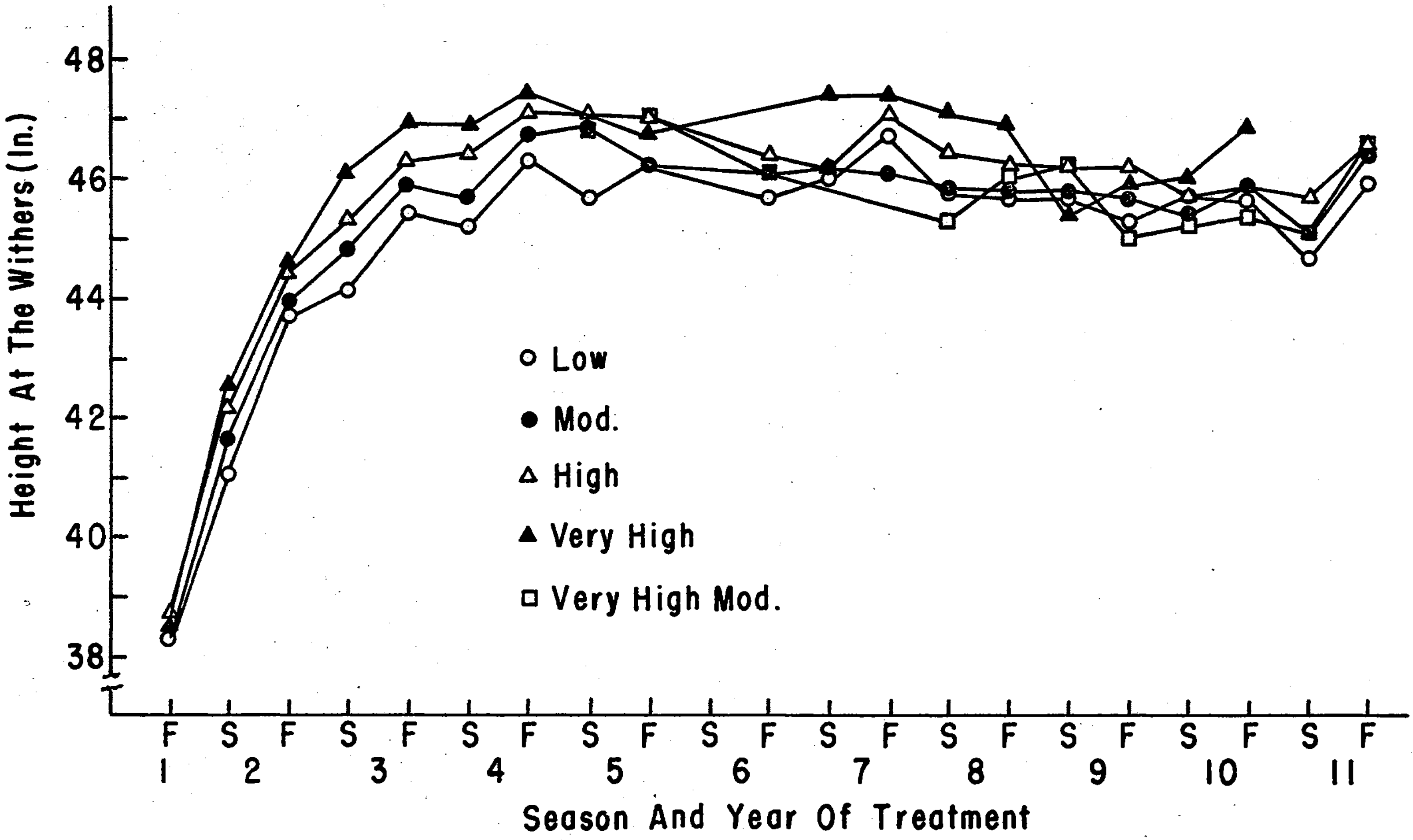

Figure 28. Average Values of Height at the Withers of Cows Fed Different Levels of Winter Nutrition

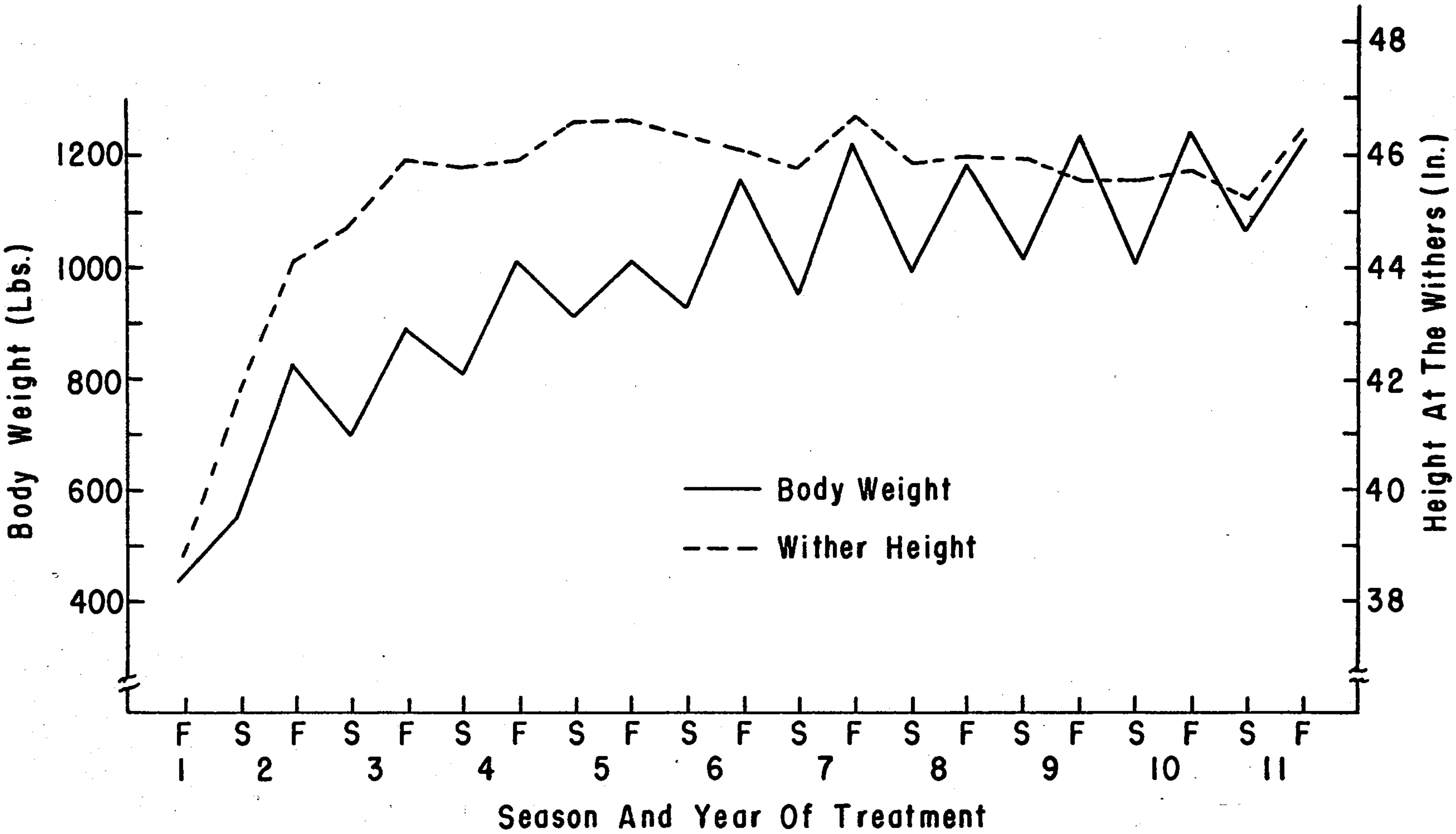

Figure 29. Average Values for Body Weight and Height at the Withers of Cows Fed the Low, Moderate, High and Very High Moderate Levels of Winter Nutrition

up to the spring of the fifth year of treatment (4 years of age). Body weights showed a very rapid increase during the first summer the heifers were on treatment and then a gradual increase each summer up to the fall weighing of the seventh year of treatment (6.5 years of age). Height at the withers, used as an indicator of skeletal development, indicates that maximum development was attained approximately 2.5 years before maximum body weights were reached by cows in the four treatments selected for this comparison. Since there appears to be a gradient in development of body parts in an anterior to posterior direction (Guilbert and Gregory, 1952), a portion of the increase in body weight after 4 years of age probably included skeletal and muscle development in the posterior region of the body as well as an increase in body fat. Data from Crichton et al. (1960a) also indicate that skeletal maturity is reached before mature body weight.

Depth of Chest

Considerable season-to-season variation was observed in the values for depth of chest (Figure 30); however, the values for spring measurements tended to level off in the fifth year of treatment (4 years of age) for cows on Low (24.58 in.), Moderate (25.65 in.), High (25.86 in.) and Very High Moderate (25.25 in.) levels. The cows on the Very High level peaked in the fall of the seventh year of treatment (28.85 in.) and then declined. Again, the pattern of the Very High level cows followed the change in feeding regime initiated in the seventh winter of treatment.

There was also a tendency for spring values to increase slightly in the latter years of the study. The nature of a beef cow is to become

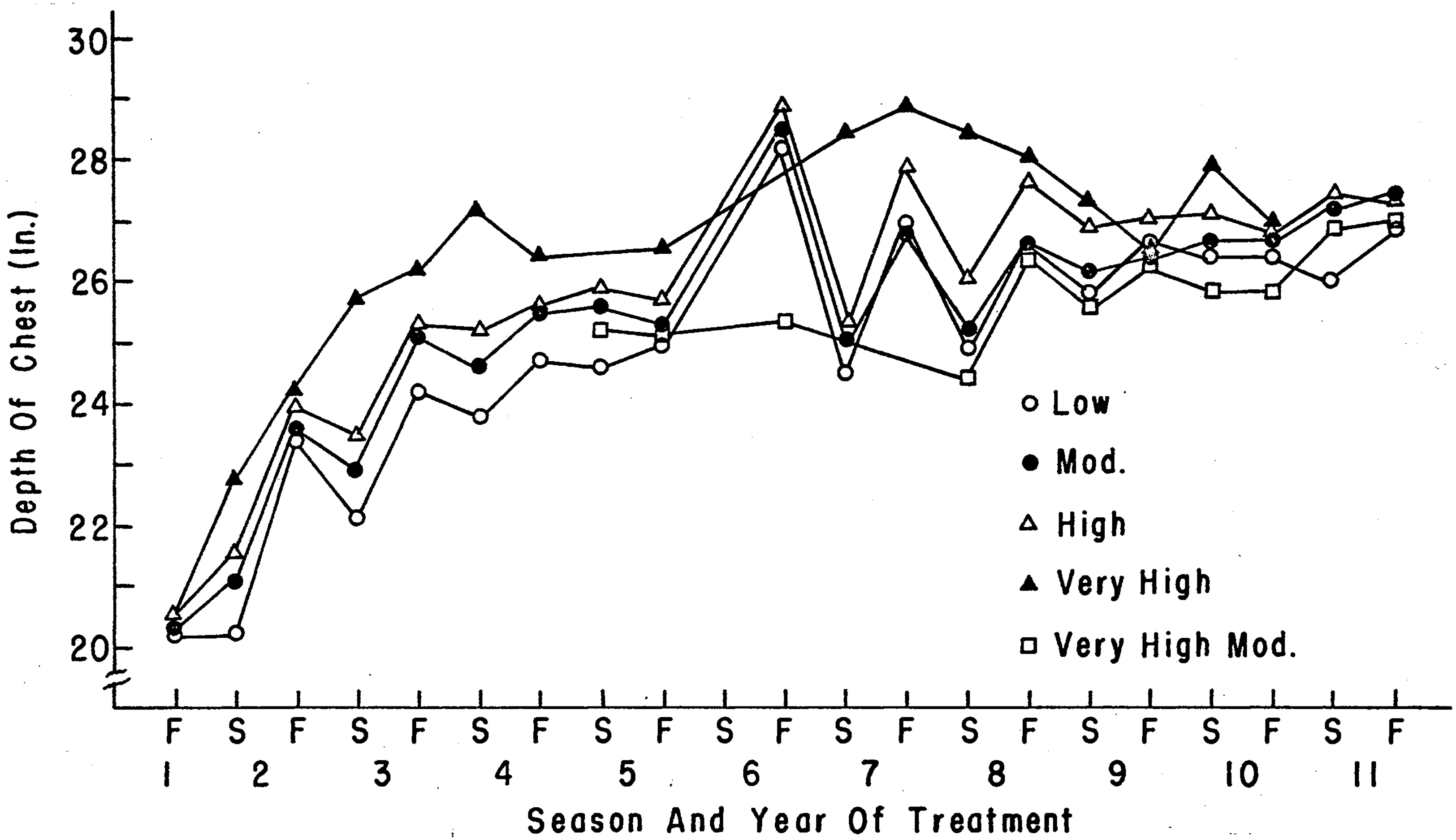

Figure 30. Average Values for Depth of Chest of Cows Fed Different Levels of Winter Nutrition

heavy-fronted with excessive brisket as she becomes older. This may have influenced the values for depth of chest which were obtained from photographs.

Distance From Chest Floor to Ground

Figure 31 indicates that values for distance from chest floor to the ground peaked in the spring of the third year of treatment (2 years of age) for cows on the Low (22.44 in.), Moderate (22.40 in.) and High (22.31 in.) levels of winter nutrition and then gradually declined. The Very High level cows peaked in the fall of the same year (21.19 in.). The increase in the values in the fall of the sixth year of treatment is not understood since it is in opposition to the trend noticed in the fall values for all other years. The gradual decline in distance from chest floor to the ground may have been due to an increase in brisket and fat in the chest floor region as the cows became older.

There was a very rapid increase in the values for this measurement from initiation of treatment up to 2 years of age. In reality, this indicates a fast rate of growth in the length of bones in the pectoral limb. Guilbert and Gregory (1952) reported that the length of the cannon bone increased rapidly and reached maturity at an early age. In all of the other body measurements, values for the Low level cows were less than those for the other treatment groups up to 4 to 6 years of age. However, Low level values for chest floor to ground were approximately the same as those for Moderate and High level cows throughout the study. This may indicate that the Low level of nutrition did not delay maturity in the early-maturing parts of the skeleton. However, it must be emphasized that the skeletal measurement and body fat were confounded.

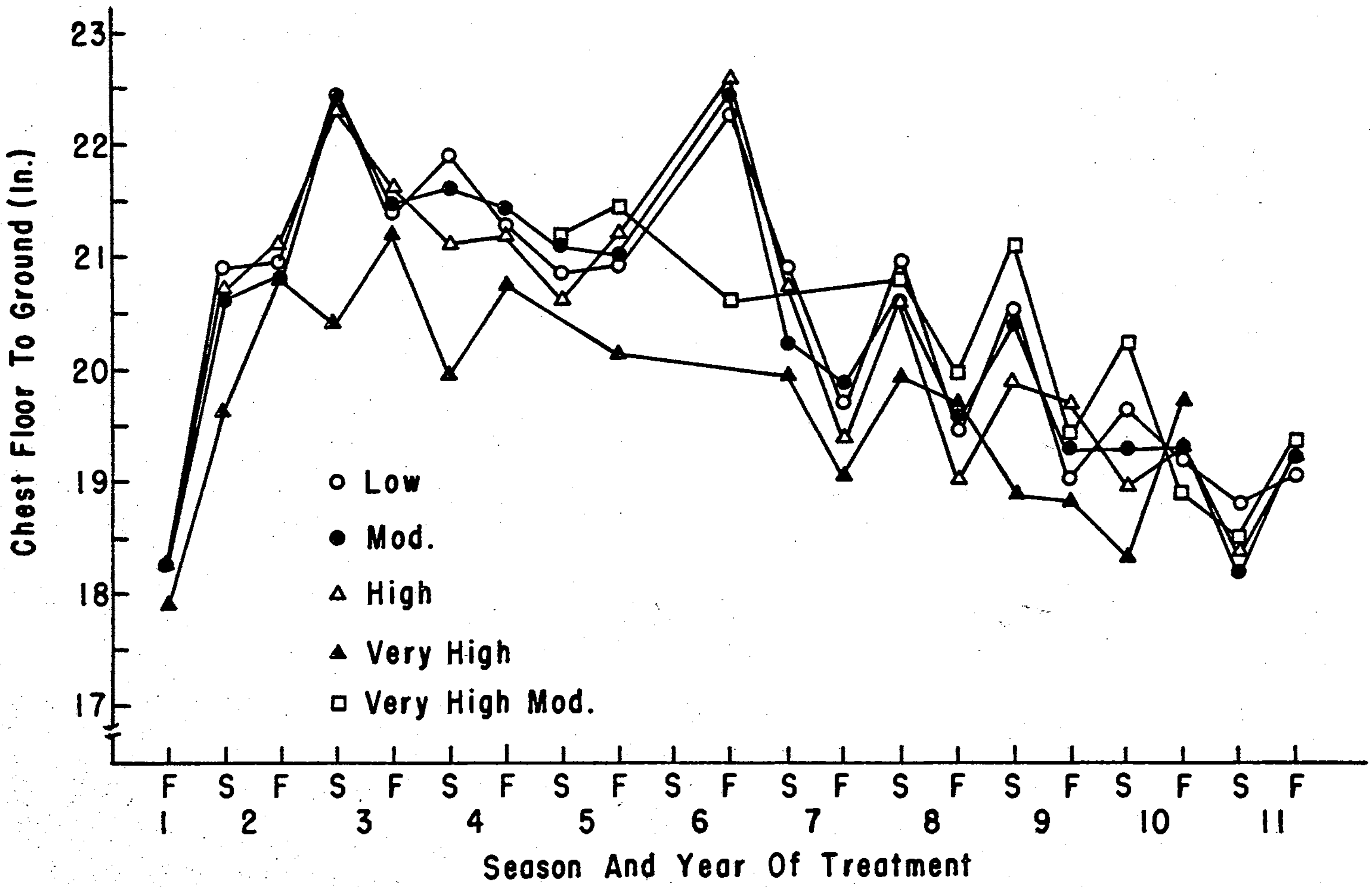

Figure 31. Average Values of Distance From Chest Floor to Ground for Cows Fed Different Levels of Winter Nutrition

Length of Body

The absence of data for the spring of the sixth year of treatment hampers determination of the plateau point for length of body (Figure 32); however, only very small increases were noted after the spring of the seventh year of treatment (6 years of age). Values for the Low, Moderate, High and Very High Moderate cows were 54.50, 54.79, 55.77 and 55.70 in. (interpolated), respectively. The peak value for Very High level cows (58.38 in.) was observed in the fall of the fifth year of treatment (4.5 years of age). These ages of maturity for length of body are similar to those reported by Crichton *et al*. (1960a). Wiltbank *et al*. (1965) observed a treatment difference of 11 cm (4.3 in.) in body length of beef heifers at time of first breeding; however, this difference disappeared after the heifers were placed on a common ration after first parturition.

General Discussion of Body Measurements

Body measurement values compare favorably with those reported by Guilbert and Gregory (1952) and Pinney (1962). Cows on the higher planes of nutrition (Very High and High) held an advantage in most of the body measurements throughout the experiment. The rank in body size, as indicated by the eight body measurements, tended to parallel the levels of winter nutrition. This was especially true up to 6 years of age. As discussed previously, the exact difference in skeletal size is difficult to determine from the data due to the influence of body fat. It was also noted that with the exception of distance from chest floor to the ground, body measurement values for the Low level cows tended to plateau at a later age than for the other groups of cows, or

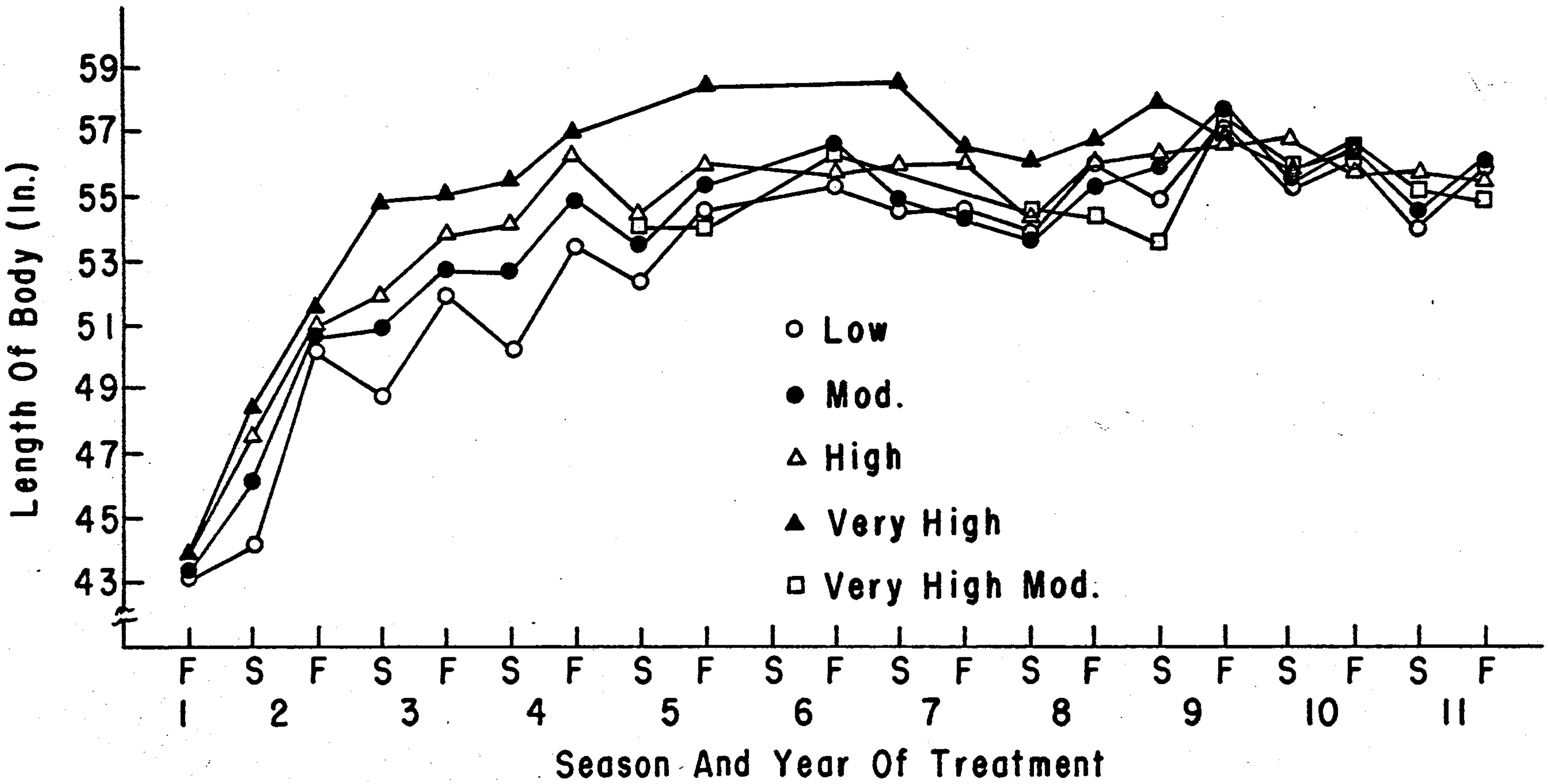

Figure 32. Average Values of Length of Body of Cows Fed Different Levels of Winter Nutrition

if they plateaued at the same age, they were smaller in absolute value. This may indicate that the Low level of nutrition delayed the age at which maturity in skeletal size was reached. Pinney *et al*. (1962) reported that a low level of winter nutrition delayed maturity and reduced mature size among heifers calving at 2 years of age. Crichton *et al*. (1960a) observed that a low level of nutrition for dairy heifers delayed maturity in skeletal size by 9 months; however, by 6 years of age, all animals had attained approximately the same body size.

Values for distance from chest floor to the ground were very similar up to six years of age for cows on Low, Moderate and High levels of winter nutrition. In light of this observation, it appears that the Low level of nutrition did not delay maturity in length of the pectoral limb, an early maturing part of the skeleton (Crichton *et al*., 1959). However, the quantitative influence of body fat on this measurement could not be determined from the data. Crichton *et al*. (1960a) concluded that the earliest maturing skeletal parts were affected the least by different levels of nutrition.

The Very High Moderate cows did not have an advantage over the Moderate level cows in any of the body measurements. This indicates that feeding the Very High level of nutrition for the first three winters did not result in earlier maturity or larger skeletal size when compared with the Moderate level.

There was some variation in the age at which the various skeletal parts reached maturity; width at the pins, 4 to 5 years; width at the hips, 4 to 5 years; width at the loin, 6 years; circumference of the heart girth, 6 years; height at the withers, 4 years; depth of chest, 4 years; distance from chest floor to the ground, 2 years; body length, 6 years. The data indicate a tendency for height and bone length in the anterior portion of the skeleton to mature earlier than width in the posterior portion; however, the pattern is not as obvious as the one described by Crichton _et al_. (1960a). Guilbert and Gregory (1952) stated that linear skeletal growth increases faster and matures earlier than growth in thickness.

The data also indicate a need for a measurement of body condition at the same time body measurements are obtained.

CHAPTER V

SUMMARY AND CONCLUSIONS

Two groups of 60 weanling Hereford heifers each were initiated on treatment in 1957 and 1958, respectively, to study the cumulative effects of various levels of winter supplemental nutrition under range conditions on growth and development, milk production and calf birth date and pre-weaning performance. The effects of age of dam and birth date and sex of calf on milk production and calf growth were also investigated. Supplemental feed allowances were adjusted periodically each winter to obtain predetermined weight changes for the Low, Moderate and High level groups. The Very High groups were self-fed a fattening ration each winter, and the Very High group initiated on treatment in 1957 was switched to the Moderate level for the fourth and subsequent winters (Very High Moderate treatment). Data through 10 winters of treatment and nine calf crops are reported.

Least squares constants indicated that the older cows (Group 1) gave more milk than the younger cows (Group 2) in 1961 (4 vs. 3 years of age), differences were minimized in 1963 and cows in Group 2 had a higher milk yield in 1964 through 1967. Calf weight paralleled milk yield. Cows which calved later in the season were usually producing more milk than cows which calved earlier when monthly milk production estimates were determined. Calves born early in the season were heavier than late-born calves in the latter stages of lactation. Cows nursing male calves tended to produce more milk at each monthly estimate in 1961 through 1963, while a complete reversal in this trend was observed in 1965 through 1967. Male calves were heavier than female calves at all monthly weighings; however, the male advantage was greater in the period 1961 through 1963.

Least squares means revealed that the High and the Moderate level cows produced more milk than cows receiving the other three treatments. The production of the Low level cows was below all other treatment groups in 1961; however, it increased at a faster rate than the production of the Very High and the Very High Moderate cows up to the 1963 lactation and exceeded production of these two treatment groups at most of the estimates thereafter. The occurrence of peak milk production varied from year to year, and the average calf age at the time of maximum milk yield ranged from 30 to 79 days.

Advantages in calf weight during lactation generally paralleled advantages in milk production of the dam. Weight advantages which were established by the time of the first weighing tended to be maintained throughout lactation. Deviations from this general observation occurred when calves declined in growth rate in the latter stages of lactation, and this was usually associated with a rapid decline in milk flow of the dam.

The Low level of winter supplemental nutrition appeared to delay attainment of maximum milk producing capacity while the Very High level of nutrition fed during the early growth stage suppressed milk flow during the latter periods of lactation. Nutritional effects on milk yield were reflected in calf weight change during lactation.

The higher levels of winter nutrition resulted in earlier calving dates in the first through the fourth calf crops. Differences between the earliest and latest average calving dates were 18, 30, 20, 17 and 13 days for the first through the fifth calf crops, respectively.

Significant treatment effects on sex-corrected calf birth weight were observed in calf crops one, two, three and nine. The average difference between the heaviest and the lightest calves was 13.4 lb. in calf crop one, and this difference was 7.8, 8.6 and 9.5 lb. in calf crops two, three and four, respectively. With the exception of the Very High group, calf birth weight closely followed the nutritional level of the dam through the fourth calf crop. Calves from the Very High level cows were lighter in the third through the sixth calf crops.

Treatment effects on age- and sex-corrected weaning weight were significant in calf crops one, two, five and six. The overall differences between heaviest (High level) and lightest (Low level) treatment groups decreased from 71.2 lb. in calf crop one to 33.3 lb. in calf crop three. Calves from the Very High Moderate level cows were always lighter at weaning than calves from the Moderate level cows. Very High level calves were lighter than the Very High Moderate calves except in calf crops six and seven.

Calf average daily gain followed the pattern observed for weaning weight. The differences between the fastest and slowest gaining groups were 0.26, 0.23, 0.16 and 0.14 lb. per day in calf crops one through four, respectively.

Performance and production of the Low level cows approached that of the High and Moderate level cows by the fourth calf crop. The data indicated that a very high level of nutrition in early life can be detrimental to the production of a beef cow when measured by calf weaning weight.

The rank in body weight and body measurements tended to parallel the levels of winter nutrition, especially up to 6 years of age. The patterns observed in the fall and spring measurements revealed that all measurements were influenced by external body fat; therefore, the absolute influence of treatments on skeletal size could not be determined. With the exception of distance from chest floor to ground, body measurements of the Low level cows either plateaued at a later age or the values were lower than measurements of cows receiving the other levels of winter nutrition. Feeding the Very High level of nutrition for the first three winters did not result in earlier maturity or larger skeletal size when compared with the Moderate level of nutrition. Height and bone length in the anterior portion of the skeleton appeared to mature earlier than width in the posterior portion. The data also indicated a need for a measurement of body condition at the same time body dimensions are measured.

LITERATURE CITED

Arnett, Dudly W. 1963. Studies with twin beef females. I. Some effects of level of nutrition. II. Milk production techniques. Ph.D. Thesis. Oklahoma State University, Stillwater, Oklahoma.

Barnicoat, C. R., P. F. Murray, E. M. Roberts and G. S. Wilson. 1956. Milk secretion studies with New Zealand Romney ewes. Parts V-XI. J. Agr. Sci. 48:9.

Bereskin, Ben and R. W. Touchberry. 1966. Some relationships of body weight and age with first-lactation yield. J. Dairy Sci. 49:869.

Bernard, C. and G. Lalande. 1967. The live weight of beef cows as influenced by age at first calving and wintering plane of nutrition. Can. J. Anim. Sci. 47:23.

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

Bond, J., J. N. Wiltbank, E. J. Warwick, R. P. Lehmann and T. B. Kinney. 1964. Feed intake and milk production of beef cows. J. Anim. Sci. 23:901. (Abstr.).

Bradford, G. E., W. C. Weir and D. T. Torell. 1961. The effect of environment from weaning to first breeding on lifetime production of ewes. J. Anim. Sci. 20:281.

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

Brody, Samuel. 1945. Bioenergetics and Growth. Reinhold Book Cooperation, New York.

Broster, W. H., V. J. Tuck and C. C. Balch. 1964. Experiments on the nutrition of the dairy heifer. V. Nutrition in late pregnancy. J. Agr. Sci. 63:51.

Brown, C. J. 1961. Weight of beef calves as influenced by year and season of birth, sire, sex and age of dam. Ark. Agr. Exp. Sta. Bull. 641.

Brown, C. J. and Larry Franks. 1964. Factors affecting size of young beef cows. J. Anim. Sci. 23:665.

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

Burgess, J. B., Nellie L. Landblom and H. H. Stonaker. 1954. Weaning weights of Hereford calves as affected by inbreeding, sex and age. J. Anim. Sci. 13:843.

Cartwright, T. C. and J. A. Carpenter. 1961. Effect of nursing habits on calf weight. J. Anim. Sci. 20:904. (Abstr.).

Castro, Alvaro, J. K. Riggs and J. B. Talcott. 1969. Factors affecting weaning weight of Santa Gertrudis range-raised calves. Tex. Agr. Exp. Sta. Consol. Prog. Rep. 2688.

Christenson, R. K., D. R. Zimmerman, D. C. Clanton, L. E. Jones, R. L. Tribble and R. Sotomayor. 1967. Effect of pre-calving energy levels on performance of beef heifers. J. Anim. Sci. 26:916. (Abstr.).

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.

Clanton, D. C. and D. R. Zimmerman. 1970. Symposium on pasture methods for maximum production in beef cattle: Protein and energy requirements for female beef cattle. J. Anim. Sci. 30:122.

Clanton, D. C., D. R. Zimmerman and R. C. Albin. 1964. Effect of protein and energy on growth and pubertal age in beef heifers. J. Anim. Sci. 23:870. (Abstr.).

Clark, R. D. and R. W. Touchberry. 1962. Effect of body weight and age at calving on milk production in Holstein cattle. J. Dairy Sci. 45:1500.

Clum, H. V., R. W. Kidder and M. Koger. 1956. Environmental factors affecting weaning weights of calves at the Florida Everglades station. J. Anim. Sci. 15:1209. (Abstr.).

Coop, I. E. 1950. The effect of level of nutrition during pregnancy and during lactation on lamb and wool production of grazing sheep. J. Agr. Sci. 40:311.

Crichton, J. A., J. N. Aitken and A. W. Boyne. 1959. The effect of plane of nutrition during rearing on growth, production, reproduction and health of dairy cattle. I. Growth to 24 months. Anim. Prod. 1:145.

Crichton, J. A., J. N. Aitken and A. W. Boyne. 1960a. The effect of plane of nutrition during rearing on growth, production, reproduction and health of dairy cattle. II. Growth to maturity. Anim. Prod. 2:45.

Crichton, J. A., J. N. Aitken and A. W. Boyne. 1960b. The effect of plane of nutrition during rearing on growth, production, reproduction and health of dairy cattle. III. Milk production during the first three lactations. Anim. Prod. 2:159.

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

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. N. Wiltbank, J. E. Ingalls and D. R. Zimmerman. 1964. Energy level and reproduction in beef females. Proc. West. Sec. Amer. Soc. Anim. Sci. 15:V-1.

Dunn, T. G., J. N. Wiltbank, D. R. Zimmerman and J. E. Ingalls. 1965. Dam's energy intake on milk production and calf gains. J. Anim. Sci. 24:586. (Abstr.).

Fitzhugh, H. A., Jr., T. C. Cartwright and R. S. Temple. 1967. Preweaning gains of beef calves with special reference to the effect of weight of dam. Tex. Agr. Exp. Sta. Consol. Prog. Rep. 2486.

Flux, D. S. 1950. The effect of undernutrition before calving on the quantity and composition of milk produced by two-year-old heifers. J. Agr. Sci. 40:177.

Furr, R. D. 1959. Levels of supplemental winter feeding of beef cattle and creep feeding fall calves. M.S. Thesis. Oklahoma State University, Stillwater, Oklahoma.

Furr, Richard Dale. 1962. Part I. Grazing behavior of range beef cows. Part II. Effect of different levels of supplemental winter feed upon the production of fall-calving beef cows. Ph.D. Thesis. Oklahoma State University, Stillwater, Oklahoma.

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.

Gardner, R. W. and D. E. Hogue. 1964. Effects of energy intake and number of lambs suckled on milk yield, milk composition and energetic efficiency of lactating ewes. J. Anim. Sci. 23:935.

Gifford, Warren. 1953. Records of performance tests for beef cattle in breeding herds. Ark. Agr. Exp. Sta. Bull. 531.

Gillooly, J. E., L. L. Wilson, C. E. Thompson, M. C. Rugh, T. A. Long and H. R. Purdy. 1967. Effects of energy level and cow size on milk yield and calf gain. J. Anim. Sci. 26:1468. (Abstr.).

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

Godley, W. C., J. F. Wise and E. G. Godbey. 1966. Effects of age and weight of dam and sex of calf on birth and weaning weight of beef calves. S.C. Agr. Exp. Sta. Tech. Bull. 1023.

Gregory, K. E., C. 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.

Guilbert, H. R. and P. W. Gregory. 1952. Some features of growth and development of Hereford cattle. J. Anim. Sci. 11:3.

Hansson, A. 1956. Influence of rearing intensity on body development and milk production. Proc. Brit. Soc. Anim. Prod. pg. 51.

Harris, R. R., W. B. Anthony and V. L. Brown. 1962. Effect of winter feeding level of beef cows upon milk production and calf performance. J. Anim. Sci. 21:385. (Abstr.).

Hight, G. K. 1966. The effects of undernutrition in late pregnancy on beef cattle production. New Zealand J. Agr. Res. 9:479.

Hobbs, C. S., G. R. Wilson and John Odom. 1965. Effect of first winter feeding level on subsequent performance of heifers calving as two-year olds. J. Anim. Sci. 24:279. (Abstr.).

Holland, G. L. 1961. The influence of excessive body fatness on the performance of beef females. Ph.D. Thesis. Oklahoma State University, Stillwater, Oklahoma.

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.).

Jamison, Haley M. 1967. Factors affecting intra-cow variation in production of beef cattle. Dissert. Abstr. 27:2931-B.

Johnson, L. E., A. L. Moxon and R. L. Smith. 1952. Wintering beef cows on South Dakota ranges. S. Dak. Agr. Exp. Sta. Bull. 419.

Joubert, D. M. 1954. The influence of winter nutritional depressions on the growth, reproduction and production of cattle. J. Agr. Sci. 44:5.

Joubert, D. M. and F. N. Bonsma. 1957. The effect of nutrition on the birth weight of calves. Union of South Africa Dept. of Agr. Sci. Bull. No. 371, Pretoria, South Africa.

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. (Abstr.).

Knapp, B., Jr., A. L. Baker and J. R. Quesenberry. 1942. Growth and production factors in range cattle. Mont. Agr. Exp. Sta. Bull. 400.

Knox, J. H. and Marvin Koger. 1945. Effect of age on the weight and production of range cows. New Mex. Agr. Exp. Sta. Press. Bull. 1004.

Knox, J. H. and W. E. Watkins. 1958. Supplements for range cows. New Mex. Agr. Exp. Sta. Bull. 425.

Koch, R. M. and R. T. Clark. 1955. Influence of sex, season of birth and age of dam on economic traits in range beef cattle. J. Anim. Sci. 14:386.

Koch, R. M., K. E. Gregory, J. E. Ingalls and R. L. Arthaud. 1959. Evaluating the influence of sex on birth weight and preweaning gain in beef cattle. J. Anim. Sci. 18:738.

Koger, Marvin and J. H. Knox. 1945. The effect of sex on weaning weight of range calves. J. Anim. Sci. 4:15.

Koger, M., W. L. Reynolds, W. G. Kirk, F. M. Peacock and A. C. Warnick. 1962. Reproductive performance of crossbred and straightbred cattle on different pasture programs in Florida. J. Anim. Sci. 21:14.

Koonce, K. L. and E. U. Dillard. 1967. Some environmental effects on birth weight and gestation length in Hereford cattle. J. Anim. Sci. 26:205. (Abstr.).

Kothmann, M. M., G. W. Mathis and P. T. Marion. 1968. Response of range cattle to three levels of protein supplementation. Tex. Agr. Exp. Sta. Consol. Prog. Rep. 2558.

Marion, P. T. and S. P. Hammack. 1969. Maintenance of beef breeding cattle. Proc. 19th Beef Short Course, Texas A & M Univ. Dept. Anim. Sci. Tech. Rep. 20:17.

Marlowe, T. J. 1962. Weights and grades of beef cattle and their relation to performance. Va. Agr. Exp. Sta. Bull. 537.

Marlowe, T. J. and J. A. Gaines. 1958. The influence of age, sex and season of birth of calf, and age of dam on preweaning growth rate and type score of beef calves. J. Anim. Sci. 17:706.

Marlowe, T. J., C. C. Mast and D. M. Sheehan. 1964. Two methods of estimating age of cow effect on calf performance. J. Anim. Sci. 23:851. (Abstr.).

Marlowe, T. J., C. C. Mast and R. R. Schalles. 1965. Some nongenetic influences on calf performance. J. Anim. Sci. 24:494.

Melton, A. A., J. K. Riggs, L. A. Nelson and T. C. Cartwright. 1966. Milk production and calf gains of Angus, Charolais and Herefords. J. Anim. Sci. 25:253. (Abstr.).

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

Melton, A. A., T. C. Cartwright and L. A. Nelson. 1967b. Cow size as related to efficiency of calf gain. J. Anim. Sci. 26:206. (Abstr.).

Minyard, J. A. and C. A. Dinkel. 1965. Weaning weight of beef calves as affected by age and sex of calf and age of dam. J. Anim. Sci. 24:1067.

Nelson, A. B., O. B. Ross, A. E. Darlow, W. D. Campbell and R. W. MacVicar. 1954. Studies on winter rations for commercial beef cows. Okla. Agr. Exp. Sta. Bull. B-418.

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.

Pahnish, O. F., E. B. Stanley, Ralph Bogart and C. B. Roubicek. 1961. Influence of sex and sire on weaning weights of Southwestern range calves. J. Anim. Sci. 20:454.

Peterson, W. E. 1942. New developments in the physiology and biochemistry of lactation, a review. J. Dairy Sci. 25:71.

Pinney, D. O. 1962. Performance of range beef cows as affected by supplemental winter feed and age at first calving. M.S. Thesis. Oklahoma State University, Stillwater, Oklahoma.

Pinney, D. O. 1963. Effect of extremes in winter nutrition on growth and reproductive performance of beef females. Ph.D. Thesis. Oklahoma State University, Stillwater, Oklahoma.

Reid, J. T. 1960. Effect of energy intake upon reproduction in farm animals. J. Dairy Sci. 43:103. (Supplement).

Reid, J. T., J. K. Loosli, G. W. Trimberger, K. L. Turk, S. A. Asdell and S. E. Smith. 1964. Causes and prevention of reproductive failures in dairy cattle. IV. Effect of plane of nutrition during early life on growth, reproduction, production, health and longevity of Holstein cows. 1. Birth to fifth calving. Cornell Univ. Agr. Exp. Sta. Bull. 987.

Reid, J. T., J. K. Loosli, K. L. Turk, G. W. Trimberger, S. A. Asdell and S. E. Smith. 1957a. Effect of nutrition during early life upon the performance of dairy cows. Proc. Cornell Nutr. Conf. pg. 65.

Reid, J. T., J. K. Loosli, K. L. Turk, S. A. Asdell and S. E. Smith. 1957b. Progress report on a study of the effect of plane of early nutrition upon reproductive and productive performance of Holstein cattle. J. Dairy Sci. 40:610. (Abstr.).

Renbarger, R. E., L. J. Smithson, D. F. Stephens and L. S. Pope. 1964. Effect of nutrition before and after calving on performance of beef heifers. J. Anim. Sci. 23:293. (Abstr.).

Riggs, J. K. 1969. Growth to weaning. Proc. 19th Beef Short Course, Texas A & M Univ. Dept. Anim. Sci. Tech. Bull. 20:61.

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

Smithson, L. J. 1966. An analysis of the relative difference in the weights of bovine males and females at birth and weaning. M.S. Thesis. Oklahoma State University, Stillwater, Oklahoma.

Smithson, Larry, S. A. Ewing, L. S. Pope and D. F. Stephens. 1966. The cumulative influence of level of wintering on the lifetime performance of beef females through six calf crops. Okla. Agr. Exp. Sta. Misc. Pub. 78:49.

Sorenson, A. M., Jr., R. W. Bratton, W. Hansel and W. H. Hough. 1954. The growth and sexual development of young Holstein heifers as influenced by three levels of nutrition. J. Anim. Sci. 13:1031. (Abstr.).

Sorenson, A. M., W. Hansel, W. H. Hough, D. T. Armstrong, K. McEntee and R. W. Bratton. 1959. Causes and prevention of reproductive failures in dairy cattle. Cornell Univ. Agr. Exp. Sta. Bull. 936.

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

Swanson, E. W. 1957. The effect of fattening dairy heifers upon their growth and lactation. J. Dairy Sci. 40:611. (Abstr.).

Swanson, E. W. 1960. Effect of rapid growth with fattening of dairy heifers on their lactational ability. J. Dairy Sci. 43:377.

Swanson, E. W. 1967. Optimum growth patterns for dairy cattle. J. Dairy Sci. 50:244.

Swanson, E. W., B. J. Bearden, E. W. Culvahouse and J. T. Miles. 1967. Restricting growth of cattle without depressing lactation. J. Dairy Sci. 50:863.

Swanson, E. W. and S. A. Hinton. 1964. Effect of seriously restricted growth upon lactation. J. Dairy Sci. 47:267.

Swanson, E. W. and T. R. Spann. 1954. The effect of rapid growth with fattening upon lactation in cattle and rats. J. Anim. Sci. 13: 1032.

Swiger, L. A. 1961. Genetic and environmental influences on gain of beef cattle during various periods of life. J. Anim. Sci. 20:183.

Swiger, L. A., R. M. Koch, K. E. Gregory, V. H. Arthaud, W. W. Rowden and J. E. Ingalls. 1962. Evaluating pre-weaning growth of beef calves. J. Anim. Sci. 21:781.

Thomson, W. and A. M. Thomson. 1953. Effect of diet on milk yield of the ewe and growth of her lamb. Brit. J. Nutr. 7:263.

Todd, J. C., H. A. Fitzhugh, Jr. and J. K. Riggs. 1969. Effects of breed and age of dam on milk yield and progeny growth. Tex. Agr. Exp. Sta. Consol. Prog. Rep. 2689.

Todd, J. C., J. K. Riggs and J. C. Smith. 1967. Milk yields and calf weights from Brahman, Hereford and crossbred cows in the Gulf Coast Prairie. Tex. Agr. Exp. Sta. Consol. Prog. Rep. 2484.

Totusek, Robert. 1968. Early weaning vs. normal weaning vs. creep feeding of heifer calves. Okla. Agr. Exp. Sta. Misc. Pub. 80:72.

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 planes of winter supplemental feeding. Okla. Agr. Exp. Sta. Misc. Pub. 76:25.

Velasco, Marcial. 1962. Level of winter feeding of range beef cows. M.S. Thesis. Oklahoma State University, Stillwater, Oklahoma.

Wallace, Joe D. and R. J. Raleigh. 1964. Calf production from Hereford cows wintered at different nutrition levels. Proc. West. Sec. Amer. Soc. Anim. Sci. 15:LVII-1.

Wiltbank, J. N., J. Bond and E. J. Warwick. 1965. Influence of total feed and protein intake on reproductive performance of the beef female through second calving. U.S.D.A. Tech. Bull. 1314.

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.

Wistrand, Glen L. and J. K. Riggs. 1968. Milk production of Santa Gertrudis cows as measured by calf nursing and machine milking methods. Tex. Agr. Exp. Sta. Consol. Prog. Rep. 2562.

Zimmerman, J. E. 1958. Effect of different levels of wintering and different ages at first calving upon performance of beef cows. M.S. Thesis. Oklahoma State University, Stillwater, Oklahoma.

Zimmerman, J. E. 1960. Part I. Effect of plane of winter nutrition on growth and reproductive performance of beef heifers. Part II. Effect of nutrient restriction on weight gains, feed utilization and body composition of male rats. Ph.D. Thesis. Oklahoma State University, Stillwater, Oklahoma.

APPENDIX

TABLE XXVII

AVERAGE MONTHLY AND YEARLY TEMPERATURE (^{o}F) AND TOTAL RAINFALL (IN.) DATA FOR EL RENO, OKLAHOMA, FOR THE YEARS 1957 THROUGH 1967[a]

Year		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave. Temperature and Total Rainfall
1957	T[b]	34.5	45.7	47.4	56.9	66.1	75.1	84.2	82.4	70.5	58.2	46.7	45.2	59.4
	R[b]	1.06	0.71	3.65	6.26	6.49	6.28	0.77	0.19	4.64	2.59	1.72	0.34	34.70
1958	T	40.1	37.1	41.5	56.6	70.0	78.0	81.1	80.8	74.1	63.3	52.2	38.3	59.4
	R	1.08	0.27	3.81	2.98	2.31	5.68	4.17	3.30	2.15	0.09	0.61	0.56	27.01
1959	T	35.2	40.6	50.8	59.9	71.0	76.9	78.0	82.8	74.0	58.8	43.8	44.4	59.7
	R	0.09	0.83	0.91	2.28	7.29	3.58	4.76	1.90	8.19	11.72	0.18	3.41	45.14
1960	T	39.1	34.9	40.3	61.9	65.5	77.6	78.1	79.1	75.1	64.0	51.8	37.1	58.5
	R	0.88	2.10	1.03	1.42	3.72	2.31	5.50	3.73	1.07	10.34	0.92	2.52	35.54
1961	T	35.6	42.4	51.8	59.0	67.9	74.9	79.8	78.8	70.5	62.9	46.2	36.4	58.8
	R	0.33	1.44	2.37	0.46	1.94	3.96	2.80	2.43	10.29	2.32	2.99	0.76	32.09
1962	T	32.5	45.4	48.9	58.3	74.3	75.0	81.8	82.2	72.2	64.6	49.2	40.7	60.4
	R	0.69	0.60	0.52	1.86	1.65	10.78	1.32	0.92	4.04	2.97	1.21	0.93	27.49
1963	T	29.2	41.6	53.6	64.5	70.6	78.9	84.3	83.3	75.3	70.5	51.5	32.6	61.3
	R	0.09	0.24	1.47	2.12	2.16	5.00	2.64	1.53	4.94	0.50	2.54	0.28	23.51
1964	T	40.8	38.7	47.9	63.8	70.7	77.5	86.1	81.5	73.2	60.2	50.2	38.1	60.7
	R	0.53	2.39	0.62	1.58	7.62	1.46	1.08	4.14	4.08	1.05	4.32	0.60	29.47
1965	T	40.1	39.7	40.6	64.8	70.0	76.2	82.9	78.6	73.2	62.7	55.1	47.2	60.9
	R	0.56	0.65	1.06	1.48	4.04	5.00	1.40	3.29	9.33	1.39	0.00	2.13	30.33
1966	T	32.8	38.8	53.7	58.7	68.1	77.8	84.6	76.6	69.4	60.0	51.0	37.0	59.0
	R	0.78	1.54	1.43	3.31	1.18	1.55	1.33	7.23	3.63	0.50	0.18	0.47	23.13
1967	T	42.3	41.9	56.0	65.2	66.4	76.9	79.1	78.0	70.0	62.6	47.4	39.2	60.4
	R	0.47	0.12	1.07	4.84	2.85	3.30	2.06	2.39	6.17	2.60	0.62	0.83	27.32

[a]Data obtained from Mr. William Curry, State Climatologist, Oklahoma City, Oklahoma.

[b]T = temperature, R = rainfall.

TABLE XXVIII

AVERAGE BIRTH DATE OF CALVES AND SUBDIVISION OF OBSERVATIONS FOR EACH MILK PRODUCTION ESTIMATE IN 1961

	Estimate				
	1	2	3	4	5
Average Birth Date	65.6	69.1	69.0	69	69.6
(70±)	-4.37	-0.88	-0.98	-0.41	-0.38
Observations	94	98	99	99	100
Older Cows	51	52	53	52	53
Younger Cows	43	46	46	47	47
Females	52	56	58	57	58
Males	42	42	41	42	42
Calves From Low	18	21	21	22	22
Calves From Mod.	24	25	25	24	25
Calves From High	27	27	27	27	27
Calves From V. High	11	12	12	12	12
Calves From V.H. Mod.	14	13	14	14	14

TABLE XXIX

AVERAGE BIRTH DATE OF CALVES AND SUBDIVISION OF OBSERVATIONS FOR EACH MILK PRODUCTION ESTIMATE IN 1962

	Estimate						
	1	2	3	4	5	6	7
Average Birth Date	50.8	70.9	64.3	64.3	64.0	64.3	64.3
(70±)	-19.17	+0.92	-5.66	-5.66	-5.98	-5.67	-5.66
Observations	18	24	44	44	43	44	44
Older Cows	--	--	--	--	--	--	--
Younger Cows	18	24	44	44	43	44	44
Females	12	10	23	23	23	23	23
Males	6	14	21	21	20	21	21
Calves From Low	2	5	9	9	9	9	9
Calves From Mod.	3	9	12	12	11	12	12
Calves From High	4	6	10	10	10	10	10
Calves From V. High	9	4	13	13	13	13	13
Calves From V.H.Mod.	--	--	--	--	--	--	--

TABLE XXX

AVERAGE BIRTH DATE OF CALVES AND SUBDIVISION OF OBSERVATIONS FOR EACH MILK PRODUCTION ESTIMATE IN 1963

	Estimate				
	1	2	3	4	5
Average Birth Date	54.1	58.6	61.3	62.4	62.1
(70±)	-15.88	-11.35	-8.69	-7.63	-7.93
Observations	74	84	87	87	87
Older Cows	39	45	48	48	47
Younger Cows	35	39	39	39	40
Females	38	41	42	42	43
Males	36	43	45	45	42
Calves From Low	15	21	22	22	20
Calves From Mod.	20	21	22	22	22
Calves From High	20	21	22	21	22
Calves From V. High	10	11	10	10	11
Calves From V.H. Mod.	9	10	11	12	12

TABLE XXXI

AVERAGE BIRTH DATE OF CALVES AND SUBDIVISION OF OBSERVATIONS FOR EACH MILK PRODUCTION ESTIMATE IN 1964

	Estimate					
	1	2	3	4	5	6
Average Birth Date	59.2	64.2	66.7	66.8	66.8	66.8
(70±)	-10.80	-5.76	-3.32	-3.16	-3.16	-3.16
Observations	76	88	91	92	92	92
Older Cows	41	51	52	53	53	53
Younger Cows	35	37	39	39	39	39
Females	39	43	43	44	44	44
Males	37	45	48	48	48	48
Calves From Low	21	24	25	25	25	25
Calves From Mod.	19	25	25	26	26	26
Calves From High	19	20	21	21	21	21
Calves From V. High	8	8	9	9	9	9
Calves From V.H. Mod.	9	11	11	11	11	11

TABLE XXXII

AVERAGE BIRTH DATE OF CALVES AND SUBDIVISION OF OBSERVATIONS FOR EACH MILK PRODUCTION ESTIMATE IN 1965

	Estimate					
	1	2	3	4	5	6
Average Birth Date	60.1	62.1	62.0	62.0	62.4	63.3
(70±)	-9.89	-7.91	-7.98	-7.98	-7.60	-6.67
Observations	81	86	88	88	86	81
Older Cows	46	48	50	50	49	45
Younger Cows	35	38	38	38	37	36
Females	37	39	40	40	39	37
Males	44	47	48	48	47	44
Calves From Low	21	21	22	22	22	21
Calves From Mod.	23	24	25	25	24	24
Calves From High	18	20	20	20	19	16
Calves From V. High	9	9	9	9	9	9
Calves From V.H. Mod.	10	12	12	12	12	11

TABLE XXXIII

AVERAGE BIRTH DATE OF CALVES AND SUBDIVISION OF OBSERVATIONS FOR EACH MILK PRODUCTION ESTIMATE IN 1966

	Estimate						
	1	2	3	4	5	6	7
Average Birth Date	57.7	61.8	69.3	68.7	68.7	69.0	68.7
(70±)	-12.26	-8.17	-0.71	-1.34	-1.34	-1.02	-1.34
Observations	66	75	82	85	85	84	85
Older Cows	39	45	50	51	51	50	51
Younger Cows	27	30	32	34	34	34	34
Females	30	35	39	39	39	39	39
Males	36	40	43	46	46	45	46
Calves From Low	18	18	20	20	20	20	20
Calves From Mod.	18	20	23	24	24	24	24
Calves From High	14	17	19	19	19	19	19
Calves From V. High	7	9	9	10	10	10	10
Calves From V.H.Mod.	9	11	11	12	12	11	12

TABLE XXXIV

AVERAGE BIRTH DATE OF CALVES AND SUBDIVISION OF OBSERVATIONS FOR EACH MILK PRODUCTION ESTIMATE IN 1967

	Estimate						
	1	2	3	4	5	6	7
Average Birth Date	55.8	58.8	66.1	66.1	66.1	66.9	66.2
(70±)	-14.20	11.21	-3.89	-3.89	-3.89	-3.09	-3.77
Observations	65	73	84	84	84	79	83
Older Cows	33	40	47	47	47	44	46
Younger Cows	32	33	37	37	37	35	37
Females	35	39	43	43	43	42	42
Males	30	34	41	41	41	37	41
Calves From Low	17	20	22	22	22	20	22
Calves From Mod.	17	19	22	22	22	20	22
Calves From High	15	17	20	20	20	19	19
Calves From V.High	8	8	9	9	9	9	9
Calves From V.H.Mod.	8	9	11	11	11	11	11

TABLE XXXV

STANDARD ERRORS OF LEAST SQUARES CONSTANTS FOR μ AND VARIABLES IN MILK PRODUCTION AND CALF WEIGHT IN LACTATION PERIOD ONE

Year	1962	1963	1964	1966	1967
Milk Production					
μ	3.15	1.11	0.89	1.04	1.17
Age of dam	a	0.83	0.71	0.87	0.91
Birth date of calf	0.158	0.046	0.033	0.038	0.044
Sex of calf	1.80	0.73	0.62	0.76	0.80
Treatment of dam					
Low-Moderate	3.19	1.07	0.83	1.00	1.09
High-Moderate	2.88	0.99	0.86	1.07	1.12
Very High-Moderate	2.50	1.29	1.12	1.45	1.45
Very High Moderate-Moderate	a	1.32	1.24	1.28	1.42
Calf Weight					
μ	11.31	5.98	5.10	4.52	5.14
Age of dam	a	4.48	4.05	3.76	4.01
Birth date of calf	0.568	0.248	0.189	0.164	0.194
Sex of calf	6.49	3.93	3.57	3.30	3.52
Treatment of dam					
Low-Moderate	11.47	5.75	4.75	4.34	4.80
High-Moderate	10.37	5.37	4.92	4.62	4.93
Very High-Moderate	9.01	6.94	6.66	6.27	6.37
Very High Moderate-Moderate	a	7.09	6.44	5.56	6.24

[a]Milk production and monthly calf weight data were not obtained from the older cows in 1962.

TABLE XXXVI

STANDARD ERRORS OF LEAST SQUARES CONSTANTS FOR μ AND VARIABLES IN MILK PRODUCTION AND CALF WEIGHT IN LACTATION PERIOD TWO

Year	1961	1962	1964	1965	1966	1967
Milk Production						
μ	0.77	1.40	0.96	0.94	1.09	1.06
Age of dam	0.70	a	0.89	0.85	0.97	0.90
Birth date of calf	0.020	0.101	0.025	0.027	0.028	0.033
Sex of calf	0.62	1.74	0.76	0.78	0.83	0.80
Treatment of dam						
Low-Moderate	0.94	2.17	1.01	1.01	1.13	1.08
High-Moderate	0.81	2.03	1.07	1.07	1.15	1.11
Very High-Moderate	1.15	2.33	1.53	1.40	1.53	1.49
Very High Moderate-Moderate	1.02	a	1.33	1.32	1.36	1.41
Calf Weight						
μ	5.33	5.51	5.44	4.86	5.91	6.26
Age of dam	4.84	a	5.09	4.37	5.26	5.29
Birth date of calf	0.139	0.396	0.141	0.141	0.150	0.192
Sex of calf	4.32	6.84	4.32	4.02	4.48	4.70
Treatment of dam						
Low-Moderate	6.53	8.51	5.76	5.20	6.14	6.35
High-Moderate	5.61	7.96	6.10	5.54	6.24	6.52
Very High-Moderate	8.03	9.16	8.72	7.21	8.29	8.76
Very High Moderate-Moderate	7.09	a	7.60	6.80	7.39	8.31

[a]Milk production and monthly calf weight data were not obtained from the older cows in 1962.

TABLE XXXVII

STANDARD ERRORS OF LEAST SQUARES CONSTANTS FOR μ AND VARIABLES IN MILK PRODUCTION AND CALF WEIGHT IN LACTATION PERIOD THREE

Year	1961	1962	1963	1964	1965	1966	1967
μ	0.89	1.22	1.00	1.11	1.08	1.17	1.13
Age of dam	0.80	a	0.87	1.10	0.97	1.08	1.02
Birth date of calf	0.018	0.042	0.026	0.023	0.026	0.019	0.020
Sex of calf	0.70	1.22	0.77	0.89	0.89	0.92	0.90
Treatment of dam							
Low-Moderate	1.05	1.81	1.09	1.20	1.19	1.26	1.23
High-Moderate	0.95	1.63	1.07	1.26	1.21	1.27	1.25
Very High-Moderate	1.27	1.56	1.36	1.75	1.61	1.75	1.71
Very High Moderate-Moderate	1.22	a	1.38	1.60	1.48	1.57	1.57
Calf Weight							
μ	7.59	8.39	6.82	7.05	7.13	6.92	7.42
Age of dam	6.78	a	5.90	6.64	6.42	6.37	6.72
Birth date of calf	0.151	0.289	0.178	0.144	0.169	0.115	0.130
Sex of calf	5.97	8.42	5.25	5.68	5.86	5.41	5.94
Treatment of dam							
Low-Moderate	8.93	12.51	7.42	7.62	7.81	7.46	8.06
High-Moderate	8.04	11.27	7.29	8.01	7.99	7.51	8.19
Very High-Moderate	10.77	10.75	9.23	11.11	10.63	10.33	11.22
Very High Moderate-Moderate	10.34	a	9.36	10.15	9.75	9.23	10.28

[a] Milk production and monthly calf weight data were not obtained from the older cows in 1962.

TABLE XXXVIII

STANDARD ERRORS OF LEAST SQUARES CONSTANTS FOR μ AND VARIABLES IN MILK PRODUCTION AND CALF WEIGHT IN LACTATION PERIOD FOUR

Year	1961	1962	1963	1964	1965	1966	1967
Milk Production							
μ	0.88	1.08	0.99	0.88	1.07	1.05	1.27
Age of dam	0.78	a	0.87	0.83	0.97	0.99	1.15
Birth date of calf	0.017	0.037	0.021	0.018	0.026	0.018	0.022
Sex of calf	0.69	1.09	0.77	0.71	0.88	0.84	1.01
Treatment of dam							
Low-Moderate	1.03	1.62	1.07	0.94	1.16	1.16	1.38
High-Moderate	0.93	1.46	1.07	0.99	1.21	1.17	1.40
Very High-Moderate	1.24	1.39	1.43	1.39	1.63	1.56	1.91
Very High Moderate-Moderate	1.17	a	1.35	1.26	1.47	1.42	1.75
Calf Weight							
μ	8.91	11.51	8.74	8.60	8.82	7.79	7.49
Age of dam	7.91	a	7.66	8.08	7.98	7.40	6.78
Birth date of calf	0.176	0.397	0.177	0.175	0.212	0.132	0.131
Sex of calf	6.96	11.54	6.75	6.91	7.26	6.26	6.00
Treatment of dam							
Low-Moderate	10.42	17.16	9.45	9.22	9.58	8.66	8.14
High-Moderate	9.39	15.45	9.38	9.71	9.96	8.74	8.26
Very High-Moderate	12.59	14.75	12.56	13.56	13.38	11.59	11.32
Very High Moderate-Moderate	11.84	a	11.91	12.31	12.12	10.55	10.38

[a]Milk production and monthly calf weight data were not obtained from the older cows in 1962.

TABLE XXXIX

STANDARD ERRORS OF LEAST SQUARES CONSTANTS FOR μ AND VARIABLES IN MILK PRODUCTION AND CALF WEIGHT IN LACTATION PERIOD FIVE

Year	1961	1962	1963	1964	1965	1966	1967
Milk Production							
μ	0.86	1.17	0.97	0.85	0.95	0.98	1.17
Age of dam	0.77	a	0.87	0.80	0.85	0.93	1.06
Birth date of calf	0.017	0.038	0.019	0.017	0.023	0.017	0.020
Sex of calf	0.67	1.11	0.76	0.68	0.78	0.79	0.94
Treatment of dam							
Low-Moderate	1.02	1.67	1.06	0.91	1.03	1.09	1.27
High Moderate	0.92	1.51	1.06	0.96	1.07	1.10	1.29
Very High-Moderate	1.22	1.43	1.41	1.34	1.43	1.46	1.77
Very High Moderate-Moderate	1.16	a	1.31	1.22	1.30	1.33	1.62
Calf Weight							
μ	10.00	14.75	9.23	9.56	9.83	9.30	8.68
Age of dam	8.92	a	8.20	8.98	8.89	8.83	7.86
Birth date of calf	0.194	0.483	0.177	0.195	0.236	0.158	0.152
Sex of calf	7.81	14.05	7.19	7.68	8.09	7.47	6.96
Treatment of dam							
Low-Moderate	11.80	21.13	10.00	10.24	10.67	10.33	9.44
High-Moderate	10.67	19.08	10.05	10.79	11.09	10.43	9.58
Very High-Moderate	14.19	18.12	13.32	15.06	14.91	13.83	13.13
Very High Moderate-Moderate	13.46	a	12.42	13.67	13.50	12.59	12.04

[a] Milk production and monthly calf weight data were not obtained from the older cows in 1962.

TABLE XL

STANDARD ERRORS OF LEAST SQUARES CONSTANTS FOR μ AND VARIABLES IN MILK PRODUCTION AND CALF WEIGHT IN LACTATION PERIOD SIX

Year	1961	1962	1964	1965	1966	1967
Milk Production						
μ	0.77	0.78	0.88	1.02	0.84	0.90
Age of dam	0.70	a	0.82	0.92	0.80	0.80
Birth date of calf	0.015	0.027	0.018	0.024	0.014	0.015
Sex of calf	0.61	0.78	0.70	0.84	0.68	0.71
Treatment of dam						
Low-Moderate	0.89	1.16	0.94	1.10	0.93	0.96
High-Moderate	0.83	1.05	0.99	1.15	0.94	0.97
Very High-Moderate	1.08	1.00	1.38	1.54	1.25	1.30
Very High Moderate-Moderate	1.02	a	1.26	1.38	1.17	1.19
Calf Weight						
μ	10.77	15.68	10.87	10.82	10.41	10.49
Age of dam	9.56	a	10.21	9.80	9.88	9.30
Birth date of calf	0.209	0.540	0.222	0.260	0.178	0.176
Sex of calf	8.41	15.72	8.74	8.89	8.40	8.23
Treatment of dam						
Low-Moderate	12.62	23.37	11.65	11.64	11.56	11.21
High-Moderate	11.41	21.05	12.27	12.18	11.66	11.25
Very High-Moderate	15.29	20.09	17.13	16.36	15.47	15.15
Very High Moderate-Moderate	14.36	a	15.55	14.66	14.43	13.80

[a]Milk production and monthly calf weight data were not obtained from the older cows in 1962.

TABLE XLI

STANDARD ERRORS OF LEAST SQUARES CONSTANTS FOR μ AND VARIABLES IN MILK PRODUCTION AND CALF WEIGHT IN LACTATION PERIOD SEVEN

Year	1962	1963	1965	1966	1967
Milk Production					
μ	1.16	0.85	0.92	1.21	1.01
Age of dam	a	0.76	0.84	1.15	0.92
Birth date of calf	0.044	0.016	0.022	0.021	0.018
Sex of calf	1.22	0.66	0.73	0.96	0.81
Treatment of dam					
Low-Moderate	1.75	0.94	0.97	1.35	1.09
High-Moderate	1.84	0.92	1.02	1.35	1.12
Very High-Moderate	1.48	1.19	1.34	1.78	1.52
Very High Moderate-Moderate	a	1.15	1.19	1.62	1.39
Calf Weight					
μ	16.17	11.37	12.61	12.12	10.81
Age of dam	a	10.17	11.52	11.51	9.81
Birth date of calf	0.56	0.218	0.304	0.206	0.189
Sex of calf	16.22	8.88	10.41	9.73	8.67
Treatment of dam					
Low-Moderate	24.11	12.63	13.48	13.46	11.67
High-Moderate	21.71	12.28	14.40	13.58	12.02
Very High-Moderate	20.72	15.94	18.70	18.02	16.24
Very High Moderate-Moderate	a	15.33	17.08	16.40	14.90

[a]Milk production and monthly calf weight data were not obtained from the older cows in 1962.

TABLE XLII

LEAST SQUARES MEANS (LB.) FOR 24-HOUR MILK PRODUCTION OF THE OLDER GROUP OF COWS IN 1961 AND 1963 THROUGH 1967 (μ + CONSTANT)

Period of Lactation	1	2	3	4	5	6	7
Year							
1961	---	12.80	12.45	11.19	9.88	9.36	---
1962[a]	---	---	---	---	---	---	---
1963	13.56	---	15.57	14.13	11.33	---	9.98
1964	14.02	15.71	14.20	12.57	9.85	10.37	---
1965	---	13.24	14.79	13.41	11.94	10.51	6.76
1966	14.70	16.16	14.90	13.67	12.61	8.11	8.17
1967	12.51	15.30	15.06	15.24	13.48	12.79	9.12

[a]Milk production estimates were not obtained for the older cows in 1962.

TABLE XLIII

LEAST SQUARES MEANS (LB.) FOR 24-HOUR MILK PRODUCTION OF COWS ON THE LOW LEVEL OF WINTER NUTRITION WITHIN PERIOD OF LACTATION WITHIN YEAR

Period of Lactation	1	2	3	4	5	6	7
Year							
1961	---	9.49 ± 0.88[a]	9.73 ± 0.97	8.53 ± 0.96	6.74 ± 0.93	5.42 ± 0.83	---
1962[b]	10.34 ± 3.67	11.42 ± 2.14	12.03 ± 1.62	11.74 ± 1.45	8.46 ± 1.47	7.99 ± 1.04	7.34 ± 1.58
1963	11.29 ± 1.08	---	14.17 ± 0.98	12.40 ± 0.96	10.60 ± 0.95	---	8.52 ± 0.84
1964	12.60 ± 0.87	14.39 ± 1.00	14.03 ± 1.12	11.04 ± 0.89	9.83 ± 0.86	10.23 ± 0.89	---
1965	---	14.13 ± 0.91	14.43 ± 1.03	13.83 ± 1.03	12.09 ± 0.91	10.72 ± 0.97	6.40 ± 0.89
1966	13.95 ± 1.01	15.16 ± 1.12	13.59 ± 1.22	13.41 ± 1.13	13.52 ± 1.06	8.32 ± 0.91	8.60 ± 1.29
1967	11.46 ± 1.09	16.95 ± 1.05	15.19 ± 1.17	16.34 ± 1.31	13.11 ± 1.21	11.95 ± 0.94	9.42 ± 1.05

[a]Standard error.

[b]Milk production estimates were not obtained for the older cows in 1962.

TABLE XLIV

LEAST SQUARES MEANS (LB.) FOR 24-HOUR MILK PRODUCTION OF COWS ON THE HIGH LEVEL OF WINTER NUTRITION WITHIN PERIOD OF LACTATION WITHIN YEAR

Period of Lactation	1	2	3	4	5	6	7
Year							
1961	---	13.46 ± 0.74[a]	12.87 ± 0.87	12.18 ± 0.85	10.09 ± 0.84	7.96 ± 0.78	---
1962[b]	13.62 ± 3.82	16.97 ± 1.60	14.58 ± 1.31	14.20 ± 1.17	8.99 ± 1.19	8.95 ± 0.84	8.13 ± 1.61
1963	16.19 ± 1.17	---	15.71 ± 0.97	15.31 ± 0.96	12.49 ± 0.96	---	10.08 ± 0.82
1964	17.61 ± 0.94	16.49 ± 1.08	14.83 ± 1.22	12.86 ± 0.97	10.76 ± 0.94	11.30 ± 0.96	---
1965	---	14.62 ± 1.10	15.84 ± 1.19	15.35 ± 1.19	13.17 ± 1.05	12.15 ± 1.12	8.12 ± 1.01
1966	14.06 ± 1.14	15.49 ± 1.18	15.63 ± 1.25	14.71 ± 1.15	12.83 ± 1.08	9.50 ± 0.93	10.51 ± 1.30
1967	15.64 ± 1.27	19.15 ± 1.15	15.58 ± 1.15	16.01 ± 1.29	13.96 ± 1.19	12.53 ± 0.87	11.51 ± 1.03

[a]Standard error.

[b]Milk production estimates were not obtained for the older cows in 1962.

TABLE XLV

LEAST SQUARES MEANS (LB.) FOR 24-HOUR MILK PRODUCTION OF COWS ON THE VERY HIGH LEVEL OF WINTER NUTRITION WITHIN PERIOD OF LACTATION WITHIN YEAR

Period of Lactation	1	2	3	4	5	6	7
Year							
1961	---	11.88 ± 0.92[a]	11.34 ± 1.02	9.49 ± 1.00	8.74 ± 0.99	8.05 ± 0.87	---
1962[b]	11.85 ± 3.56	15.72 ± 1.90	12.37 ± 1.31	12.02 ± 1.17	8.17 ± 1.19	7.13 ± 0.84	7.52 ± 1.26
1963	12.33 ± 1.39	---	11.87 ± 1.14	10.75 ± 1.19	9.54 ± 1.16	---	8.00 ± 0.98
1964	15.70 ± 1.14	12.26 ± 1.36	12.92 ± 1.46	10.22 ± 1.16	9.32 ± 1.12	8.50 ± 1.16	---
1965	---	13.17 ± 1.20	13.84 ± 1.42	12.53 ± 1.43	11.67 ± 1.26	12.23 ± 1.34	5.69 ± 1.13
1966	13.62 ± 1.28	14.55 ± 1.19	14.02 ± 1.40	11.30 ± 1.23	11.84 ± 1.16	7.37 ± 0.99	8.78 ± 1.39
1967	12.50 ± 1.34	14.72 ± 1.34	12.10 ± 1.44	13.66 ± 1.61	10.66 ± 1.49	9.88 ± 1.08	8.78 ± 1.28

[a]Standard error.

[b]Milk production estimates were not obtained for the older cows in 1962.

TABLE XLVI

LEAST SQUARES MEANS (LB.) FOR 24-HOUR MILK PRODUCTION OF COWS ON THE VERY HIGH MODERATE LEVEL OF WINTER NUTRITION WITHIN PERIOD OF LACTATION WITHIN YEAR

Period of Lactation	1	2	3	4	5	6	7
Year							
1961	---	11.80 ± 1.10[a]	11.73 ± 1.30	10.25 ± 1.26	8.39 ± 1.23	6.97 ± 1.10	---
1962[b]							
1963	11.92 ± 1.41	---	13.04 ± 1.44	12.08 ± 1.42	9.20 ± 1.35	---	8.30 ± 1.18
1964	13.55 ± 1.22	14.28 ± 1.42	14.10 ± 1.68	11.04 ± 1.33	8.80 ± 1.29	9.81 ± 1.33	---
1965	---	12.15 ± 1.41	12.52 ± 1.52	12.85 ± 1.53	11.94 ± 1.35	9.59 ± 1.44	7.78 ± 1.29
1966	13.81 ± 1.44	15.44 ± 1.50	13.93 ± 1.69	13.20 ± 1.51	10.73 ± 1.42	8.56 ± 1.25	9.30 ± 1.71
1967	11.20 ± 1.61	16.31 ± 1.58	13.13 ± 1.71	15.49 ± 1.92	10.87 ± 1.77	9.71 ± 1.31	8.37 ± 1.53

[a]Standard error.

[b]Milk production estimates were not obtained for the older cows in 1962.

TABLE XLVII

LEAST SQUARES MEANS (LB.) FOR WEIGHT OF CALVES FROM COWS ON THE LOW LEVEL OF WINTER NUTRITION WITHIN PERIOD OF LACTATION WITHIN YEAR

Period of Lactation	1	2	3	4	5	6	7
Year							
1961	---	119.8 ± 6.12[a]	194.9 ± 8.22	259.2 ± 9.71	309.9 ± 10.79	360.0 ± 11.61	---
1962[b]	76.9 ± 8.62	129.8 ± 8.39	184.2 ±11.20	276.7 ±15.36	353.6 ± 18.60	411.8 ± 20.92	450.2 ± 21.61
1963	97.6 ± 5.83	---	192.8 ± 6.64	263.4 ± 8.44	349.5 ± 8.95	---	429.9 ± 11.30
1964	106.2 ± 4.99	161.7 ± 5.71	233.6 ± 7.16	298.6 ± 8.72	339.3 ± 9.68	389.9 ± 11.02	---
1965	---	134.8 ± 4.71	211.8 ± 6.76	294.4 ± 8.50	346.6 ± 9.47	397.2 ± 10.26	480.8 ± 11.82
1966	97.1 ± 4.37	144.1 ± 6.09	217.4 ± 7.21	260.5 ± 8.40	332.3 ± 10.03	383.1 ± 11.22	448.8 ± 13.06
1967	100.1 ± 4.79	158.4 ± 6.17	200.1 ± 7.70	259.8 ± 7.77	335.6 ± 9.01	386.4 ± 10.99	443.6 ± 11.22

[a]Standard error.

[b]Monthly weights were not obtained for calves from the older group of cows in 1962.

TABLE XLVIII

LEAST SQUARES MEANS (LB.) FOR WEIGHT OF CALVES FROM COWS ON THE HIGH LEVEL OF WINTER NUTRITION WITHIN PERIOD OF LACTATION WITHIN YEAR

Period of Lactation	1	2	3	4	5	6	7
Year							
1961	---	152.1 ± 5.16[a]	236.8 ± 7.36	306.1 ± 8.67	363.2 ± 9.70	417.0 ± 10.44	---
1962[b]	86.8 ± 9.44	140.4 ± 6.26	210.4 ± 9.03	307.5 ±12.38	384.7 ±15.01	441.8 ± 16.87	474.1 ± 17.40
1963	122.3 ± 4.98	---	217.5 ± 6.62	292.3 ± 8.43	374.4 ± 8.95	---	456.6 ± 10.96
1964	137.2 ± 5.38	196.8 ± 6.17	271.6 ± 7.76	335.6 ± 9.45	376.7 ±10.50	429.4 ± 11.95	---
1965	---	155.9 ± 5.65	226.9 ± 7.83	311.7 ± 9.79	364.1 ±10.91	413.4 ± 11.87	510.0 ± 14.29
1966	107.1 ± 4.96	159.2 ± 6.38	227.8 ± 7.37	270.2 ± 8.58	339.1 ±10.25	389.4 ± 11.47	455.8 ± 13.35
1967	127.7 ± 5.56	188.8 ± 6.77	219.2 ± 7.56	283.6 ± 7.64	356.4 ± 8.85	410.8 ± 10.18	467.5 ± 10.97

[a]Standard error.

[b]Monthly weights were not obtained for calves from the older group of cows in 1962.

TABLE XLIX

LEAST SQUARES MEANS (LB.) FOR WEIGHT OF CALVES FROM COWS ON THE VERY HIGH LEVEL OF WINTER NUTRITION WITHIN PERIOD OF LACTATION WITHIN YEAR

Period of Lactation	1	2	3	4	5	6	7
Year							
1961	---	131.7 ± 6.42[a]	212.0 ± 8.70	277.0 ±10.18	331.1 ±11.45	383.5 ±12.35	---
1962[b]	82.1 ± 7.98	123.7 ± 7.45	192.9 ± 9.02	280.8 ±12.37	359.8 ±15.07	409.9 ±16.86	438.3 ±17.38
1963	113.4 ± 7.51	---	188.1 ± 7.76	253.7 ±11.19	342.3 ±10.99	---	404.8 ±13.12
1964	127.5 ± 6.55	178.1 ± 7.75	238.8 ± 9.30	296.7 ±11.36	334.1 ±12.62	374.1 ±14.36	---
1965	---	144.0 ± 6.21	210.2 ± 9.34	293.8 ±11.74	342.8 ±13.08	393.3 ±14.19	479.8 ±16.21
1966	109.1 ± 5.56	156.7 ± 6.47	228.4 ± 8.27	265.8 ± 9.19	331.0 ±10.97	377.0 ±12.27	440.6 ±14.29
1967	105.8 ± 5.90	168.0 ± 7.85	200.2 ± 9.47	255.8 ± 9.56	326.9 ±11.09	377.2 ±12.59	430.4 ±13.73

[a]Standard error.

[b]Monthly weights were not obtained for calves from the older group of cows in 1962.

TABLE L

LEAST SQUARES MEANS (LB.) FOR WEIGHT OF CALVES FROM COWS ON THE VERY HIGH MODERATE LEVEL OF WINTER NUTRITION WITHIN PERIOD OF LACTATION WITHIN YEAR

Period of Lactation	1	2	3	4	5	6	7
Year							
1961	---	133.8 ± 7.65[a]	209.4 ±11.03	274.4 ±12.78	326.1 ±14.34	381.5 ±15.41	---
1962[b]							
1963	107.6 ± 7.60	---	195.4 ± 9.76	272.2 ±12.48	359.9 ±12.82	---	435.9 ±15.82
1964	119.8 ± 7.01	175.1 ± 8.11	245.2 ±10.70	307.5 ±13.04	343.6 ±14.49	390.4 ±16.49	---
1965	---	132.0 ± 7.25	206.1 ±10.04	286.6 ±12.56	336.1 ±14.00	384.5 ±15.26	460.8 ±18.10
1966	95.6 ± 6.25	146.6 ± 8.12	219.3 ± 9.95	255.0 ±11.28	322.7 ±13.46	376.5 ±15.47	434.0 ±17.54
1967	113.9 ± 7.08	172.8 ± 9.28	207.5 ±11.24	265.4 ±11.35	341.4 ±13.15	389.8 ±15.30	445.7 ±16.39

[a]Standard error.

[b]Monthly weights were not obtained for calves from the older group of cows in 1962.

TABLE LI

AVERAGE CALVING DATE FOR COWS FED DIFFERENT LEVELS OF WINTER NUTRITION

Treatment	Low	Moderate	High	Very High	Very High Moderate
Calf Crop					
1	78.96[a] ± 4.09[b]	72.93 ± 3.88	61.59 ± 4.09	61.25 ± 4.02	
2	89.88 ± 4.38	73.15 ± 4.13	60.24 ± 4.29	66.03 ± 4.05	
3	76.68 ± 3.62	66.12 ± 3.39	63.16 ± 3.39	57.15 ± 4.71	62.07 ± 4.54
4	67.88 ± 2.87	58.85 ± 2.74	58.74 ± 2.92	50.67 ± 4.04	57.54 ± 3.88
5	66.46 ± 4.29	60.36 ± 4.20	57.39 ± 4.38	62.75 ± 6.06	70.17 ± 6.06
6	69.12 ± 3.75	68.42 ± 3.61	62.42 ± 3.75	63.27 ± 5.54	73.25 ± 5.31
7	61.68 ± 4.86	68.76 ± 4.56	60.22 ± 4.75	66.80 ± 7.20	60.42 ± 6.58
8	64.30 ± 4.65	68.36 ± 4.46	70.10 ± 4.87	57.89 ± 7.43	67.67 ± 6.44
9[c]	71.79 ± 6.62	68.00 ± 6.87	62.00 ± 7.47		68.83 ± 7.16

[a]Day of the year, January 1 = day 1.

[b]Standard error.

[c]Includes only calves from older group of cows.

TABLE LII

AVERAGE SEX-CORRECTED BIRTH WEIGHT (LB.) OF CALVES FROM COWS FED DIFFERENT LEVELS OF WINTER NUTRITION

Treatment	Low	Moderate	High	Very High	Very High Moderate
Calf Crop					
1	57.93 ± 1.39[a]	66.87 ± 1.32	71.33 ± 1.39	68.14 ± 1.36	
2	69.46 ± 1.79	74.59 ± 1.68	77.24 ± 1.75	74.86 ± 1.65	
3	76.32 ± 1.63	79.52 ± 1.53	80.72 ± 1.53	72.15 ± 2.12	78.79 ± 2.05
4	80.33 ± 1.90	79.62 ± 1.82	81.39 ± 1.94	71.92 ± 2.68	77.23 ± 2.58
5	79.04 ± 1.48	78.64 ± 1.45	81.91 ± 1.51	75.08 ± 2.10	78.83 ± 2.10
6	80.67 ± 1.60	80.38 ± 1.54	80.88 ± 1.60	80.82 ± 2.36	81.50 ± 2.26
7	79.27 ± 1.95	79.72 ± 1.83	77.57 ± 1.91	80.30 ± 2.90	80.17 ± 2.64
8	79.39 ± 1.84	79.00 ± 1.77	83.14 ± 1.93	78.00 ± 2.94	81.08 ± 2.55
9	72.79 ± 2.73	79.00 ± 2.83	84.00 ± 3.08		82.08 ± 2.95

[a]Standard error.

[b]Includes only calves from older group of cows.

TABLE LIII

AVERAGE AGE- AND SEX-CORRECTED WEANING WEIGHT (LB.) OF CALVES
FROM COWS FED DIFFERENT LEVELS OF WINTER NUTRITION

Treatment	Low	Moderate	High	Very High	Very High Moderate
Calf Crop					
1	338.5 ± 9.83[a]	397.0 ± 9.83	409.7 ± 9.83	394.4 ± 11.05	
2	420.0 ± 11.10	463.8 ± 10.62	479.7 ± 10.85	449.4 ± 10.62	
3	448.6 ± 10.79	474.0 ± 9.89	481.9 ± 10.09	450.1 ± 13.72	453.3 ± 13.22
4	471.0 ± 9.27	481.2 ± 9.27	480.3 ± 10.15	443.1 ± 14.36	457.2 ± 13.69
5	476.6 ± 10.95	475.6 ± 10.95	503.3 ± 12.00	434.1 ± 16.97	472.2 ± 16.18
6	476.6 ± 8.95	487.1 ± 8.77	516.1 ± 9.81	484.6 ± 14.61	465.3 ± 13.22
7	495.1 ± 10.03	489.7 ± 8.92	502.8 ± 10.03	499.5 ± 13.82	457.8 ± 12.62
8	495.8 ± 10.41	495.5 ± 10.41	509.3 ± 10.89	469.0 ± 16.63	479.8 ± 14.41
9	479.0 ± 11.82	480.3 ± 11.36	496.5 ± 12.35		475.9 ± 12.35

[a]Standard error.

[b]Includes only calves from the older group of cows.

TABLE LIV

AVERAGE DAILY GAIN (LB.) FROM BIRTH TO WEANING OF CALVES FROM COWS FED DIFFERENT LEVELS OF WINTER NUTRITION

Treatment	Low	Moderate	High	Very High	Very High Moderate
Calf Crop					
1	1.30 ± 0.045[a]	1.51 ± 0.045	1.56 ± 0.045	1.50 ± 0.051	
2	1.62 ± 0.050	1.78 ± 0.048	1.85 ± 0.049	1.73 ± 0.048	
3	1.70 ± 0.049	1.82 ± 0.045	1.86 ± 0.046	1.74 ± 0.062	1.78 ± 0.060
4	1.82 ± 0.043	1.86 ± 0.042	1.84 ± 0.044	1.72 ± 0.064	1.78 ± 0.061
5	1.83 ± 0.049	1.84 ± 0.049	1.95 ± 0.054	1.67 ± 0.076	1.81 ± 0.073
6	1.84 ± 0.040	1.88 ± 0.039	2.01 ± 0.044	1.85 ± 0.066	1.77 ± 0.059
7	1.93 ± 0.042	1.89 ± 0.038	1.95 ± 0.042	1.95 ± 0.059	1.77 ± 0.053
8	1.91 ± 0.045	1.93 ± 0.045	1.97 ± 0.047	1.80 ± 0.072	1.85 ± 0.062
9[b]	1.87 ± 0.057	1.86 ± 0.055	1.92 ± 0.060		1.80 ± 0.060

[a]Standard error.

[b]Includes only calves from the older group of cows.

TABLE LV

AVERAGE BODY WEIGHTS (LB.) OF COWS FED DIFFERENT LEVELS OF WINTER NUTRITION

Treatment		Low	Moderate	High	Very High	Very High Moderate
Year of Treatment	Season[a]					
1	F	474 ± 9.2[b]	472 ± 9.2	473 ± 9.2	472 ± 9.2	
2	S	462 ± 10.9	569 ± 10.8	619 ± 10.9	746 ± 10.8	
	F	788 ± 11.5	829 ± 11.1	859 ± 11.3	891 ± 11.1	
3	S	574 ± 15.2	712 ± 14.6	778 ± 15.2	1063 ± 15.4	
	F	841 ± 18.2	906 ± 17.8	941 ± 18.2	1053 ± 18.5	
4	S	688 ± 20.5	834 ± 19.3	892 ± 19.7	1174 ± 19.0	
	F	944 ± 21.5	1030 ± 20.2	1064 ± 21.5	1183 ± 20.6	
5	S	797 ± 21.3	923 ± 20.0	995 ± 20.0	1438 ± 27.8	925 ± 26.8
	F	1071 ± 22.6	1118 ± 21.6	1160 ± 21.2	1328 ± 29.4	1079 ± 28.3
6	S	850 ± 21.8	943 ± 20.9	1020 ± 22.3	1506 ± 31.6	917 ± 30.2
	F	1106 ± 21.6	1175 ± 20.8	1200 ± 21.6	1425 ± 31.3	1124 ± 30.0
7	S	871 ± 23.9	932 ± 25.0	1048 ± 25.0	1621 ± 33.8	928 ± 37.0
	F	1179 ± 23.9	1223 ± 23.9	1275 ± 24.4	1471 ± 35.3	1195 ± 33.8
8	S	861 ± 25.0	981 ± 24.5	1141 ± 27.4	1364 ± 40.8	967 ± 35.3
	F	1131 ± 23.8	1184 ± 22.4	1262 ± 23.3	1374 ± 40.4	1153 ± 36.1
9	S	925 ± 27.4	1000 ± 25.7	1148 ± 27.4	1242 ± 42.8	971 ± 38.7
	F	1218 ± 24.5	1220 ± 23.5	1293 ± 25.7	1304 ± 40.7	1198 ± 33.2
10	S	970 ± 29.0	1065 ± 27.8	1175 ± 30.4	1256 ± 45.3	1010 ± 39.3
	F	1224 ± 24.9	1254 ± 23.9	1298 ± 26.2	1323 ± 41.4	1194 ± 35.3
11[c]	S	964 ± 38.7	1104 ± 38.7	1135 ± 42.1		1059 ± 42.1
	F	1200 ± 33.7	1257 ± 35.1	1242 ± 38.5		1230 ± 35.1

[a]F = fall, S = spring.

[b]Standard error.

[c]Weights from the older group of cows.

TABLE LVI

AVERAGE WIDTH (INCHES) AT THE PINS OF COWS FED
DIFFERENT LEVELS OF WINTER NUTRITION

Treatment Year of Treatment	Season[a]	Low	Moderate	High	Very High	Very High Moderate
1	F	8.02 ± 0.09[b]	8.18 ± 0.09	8.06 ± 0.09	8.21 ± 0.09	
2	S	8.47 ± 0.10	9.26 ± 0.10	9.91 ± 0.10	10.28 ± 0.10	
	F	10.93 ± 0.10	11.28 ± 0.10	11.64 ± 0.10	11.62 ± 0.10	
3	S	9.86 ± 0.12	11.11 ± 0.12	11.32 ± 0.12	12.48 ± 0.12	
	F	11.63 ± 0.18	11.84 ± 0.18	12.06 ± 0.18	12.59 ± 0.18	
4	S	10.52 ± 0.18	11.81 ± 0.16	12.03 ± 0.17	13.33 ± 0.16	
	F	11.47 ± 0.17	12.49 ± 0.16	12.50 ± 0.17	12.99 ± 0.17	
5	S	10.98 ± 0.18	11.85 ± 0.18	12.32 ± 0.18		11.93 ± 0.18
	F	12.18 ± 0.15	12.52 ± 0.14	12.60 ± 0.14	12.77 ± 0.20	12.57 ± 1.90
6	S					
	F	11.57 ± 0.16	12.07 ± 0.15	11.64 ± 0.16		12.58 ± 0.22
7	S	11.64 ± 0.34	11.83 ± 0.33	12.50 ± 0.36	13.59 ± 0.34	
	F	12.61 ± 0.19	12.82 ± 0.19	13.53 ± 0.20	12.50 ± 0.19	
8	S	11.39 ± 0.15	11.93 ± 0.15	11.97 ± 0.17	11.97 ± 0.25	12.00 ± 0.22
	F	12.39 ± 0.17	12.57 ± 0.16	12.79 ± 0.17	12.81 ± 0.28	12.68 ± 0.26
9	S	11.59 ± 0.15	11.95 ± 0.14	12.00 ± 0.15	12.89 ± 0.23	11.67 ± 0.21
	F	12.67 ± 0.17	12.84 ± 0.16	12.96 ± 0.18	12.81 ± 0.28	12.31 ± 0.23
10	S	11.54 ± 0.18	12.29 ± 0.17	12.50 ± 0.19	12.50 ± 0.28	12.06 ± 0.24
	F	12.62 ± 0.22	12.64 ± 0.21	12.59 ± 0.24	12.61 ± 0.34	12.74 ± 0.31
11[c]	S	11.46 ± 0.26	12.23 ± 0.26	12.09 ± 0.28		12.04 ± 0.27
	F	12.23 ± 0.25	12.46 ± 0.25	11.72 ± 0.28		12.46 ± 0.26

[a]F = fall, S = spring.

[b]Standard error.

[c]Measurements from the older group of cows.

TABLE LVII

AVERAGE WIDTH (INCHES) AT THE HIPS OF COWS FED DIFFERENT LEVELS OF WINTER NUTRITION

Treatment		Low	Moderate	High	Very High	Very High Moderate
Year of Treatment	Season[a]					
1	F	13.42 ± 0.12[b]	13.48 ± 0.12	13.35 ± 0.12	13.42 ± 0.12	
2	S	13.93 ± 0.14	14.96 ± 0.13	15.42 ± 0.14	16.62 ± 0.13	
	F	17.86 ± 0.13	18.25 ± 0.12	18.36 ± 0.12	18.82 ± 0.12	
3	S	16.69 ± 0.18	17.66 ± 0.17	18.28 ± 0.18	20.74 ± 0.18	
	F	18.94 ± 0.19	19.84 ± 0.19	19.96 ± 0.19	21.15 ± 0.19	
4	S	18.20 ± 0.20	19.55 ± 0.19	19.93 ± 0.20	22.51 ± 0.19	
	F	19.67 ± 0.22	20.97 ± 0.21	21.04 ± 0.22	21.93 ± 0.22	
5	S	19.37 ± 0.25	20.40 ± 0.25	20.82 ± 0.24		20.41 ± 0.24
	F	20.72 ± 0.22	21.43 ± 0.21	21.52 ± 0.21	22.75 ± 0.29	21.32 ± 0.28
6	S					
	F	20.86 ± 0.21	21.62 ± 0.20	21.53 ± 0.21		21.42 ± 0.29
7	S	20.41 ± 0.28	20.83 ± 0.27	21.30 ± 0.30	24.08 ± 0.27	
	F	21.86 ± 0.40	22.20 ± 0.40	22.95 ± 0.42	24.09 ± 0.40	
8	S	20.28 ± 0.21	21.04 ± 0.20	21.42 ± 0.23	22.94 ± 0.34	20.83 ± 0.29
	F	21.24 ± 0.25	21.84 ± 0.24	22.38 ± 0.25	22.44 ± 0.40	21.84 ± 0.38
9	S	20.44 ± 0.21	20.81 ± 0.20	21.52 ± 0.22	21.92 ± 0.33	20.90 ± 0.30
	F	20.99 ± 0.29	21.35 ± 0.27	21.62 ± 0.30	21.06 ± 0.48	21.56 ± 0.39
10	S	20.58 ± 0.22	21.06 ± 0.21	21.49 ± 0.23	21.83 ± 0.34	21.10 ± 0.30
	F	20.93 ± 0.24	21.61 ± 0.23	21.02 ± 0.26	22.19 ± 0.37	20.86 ± 0.34
11[c]	S	20.04 ± 0.33	20.77 ± 0.33	21.27 ± 0.35		21.04 ± 0.34
	F	20.79 ± 0.36	21.44 ± 0.36	20.90 ± 0.41		21.35 ± 0.37

[a]F = fall, S = spring.

[b]Standard error.

[c]Measurements from the older group of cows.

TABLE LVIII

AVERAGE WIDTH (INCHES) AT THE LOIN OF COWS FED DIFFERENT LEVELS OF WINTER NUTRITION

Treatment		Low	Moderate	High	Very High	Very High Moderate
Year of Treatment	Season[a]					
1	F	7.99 ± 0.09[b]	8.23 ± 0.09	8.27 ± 0.09	8.10 ± 0.09	
2	S	8.70 ± 0.13	9.45 ± 0.13	9.90 ± 0.13	11.44 ± 0.13	
	F	11.21 ± 0.12	11.76 ± 0.11	12.09 ± 0.11	12.28 ± 0.11	
3	S	10.54 ± 0.16	11.22 ± 0.16	11.66 ± 0.16	13.92 ± 0.16	
	F	12.22 ± 0.17	13.14 ± 0.16	13.38 ± 0.17	14.41 ± 0.17	
4	S	11.10 ± 0.17	12.60 ± 0.16	12.63 ± 0.17	15.38 ± 0.16	
	F	12.98 ± 0.19	13.88 ± 0.18	13.76 ± 0.19	14.79 ± 0.18	
5	S	11.73 ± 0.25	12.94 ± 0.25	12.84 ± 0.24		13.02 ± 0.24
	F	12.52 ± 0.20	13.06 ± 0.19	13.52 ± 0.19	14.71 ± 0.26	13.12 ± 0.25
6	S					
	F	12.66 ± 0.19	13.36 ± 0.18	13.58 ± 0.19		12.94 ± 0.26
7	S	13.73 ± 0.25	14.00 ± 0.24	14.60 ± 0.26	16.54 ± 0.24	
	F	13.57 ± 0.28	13.73 ± 0.28	14.88 ± 0.30	15.55 ± 0.28	
8	S	13.36 ± 0.18	14.10 ± 0.18	14.50 ± 0.20	15.22 ± 0.29	13.96 ± 0.25
	F	13.60 ± 0.19	13.88 ± 0.18	14.63 ± 0.19	15.25 ± 0.31	13.90 ± 0.30
9	S	13.42 ± 0.17	13.85 ± 0.16	14.05 ± 0.18	14.72 ± 0.27	13.69 ± 0.24
	F	14.05 ± 0.27	14.10 ± 0.26	14.51 ± 0.28	15.37 ± 0.44	13.90 ± 0.36
10	S	13.02 ± 0.20	13.67 ± 0.19	14.11 ± 0.21	14.33 ± 0.31	13.90 ± 0.27
	F	13.84 ± 0.25	14.41 ± 0.24	13.97 ± 0.27	14.58 ± 0.39	14.02 ± 0.35
11[c]	S	12.50 ± 0.25	13.31 ± 0.25	13.50 ± 0.27		13.29 ± 0.26
	F	13.27 ± 0.30	13.83 ± 0.30	13.88 ± 0.34		13.96 ± 0.31

[a] F = fall, S = spring.

[b] Standard error.

[c] Measurements from the older group of cows.

TABLE LIX

AVERAGE CIRCUMFERENCE (INCHES) OF THE HEART GIRTH OF COWS FED DIFFERENT LEVELS OF WINTER NUTRITION

Treatment		Low	Moderate	High	Very High	Very High Moderate
Year of Treatment	Season[a]					
1	F	53.67 ± 0.43[b]	53.70 ± 0.43	54.05 ± 0.43	53.91 ± 0.43	
2	S	53.69 ± 0.42	57.27 ± 0.42	59.88 ± 0.42	65.30 ± 0.42	
	F	65.59 ± 0.37	67.22 ± 0.36	68.19 ± 0.37	69.00 ± 0.36	
3	S	59.30 ± 0.46	63.00 ± 0.45	65.70 ± 0.46	74.48 ± 0.47	
	F	66.84 ± 0.51	68.68 ± 0.50	69.76 ± 0.51	73.19 ± 0.52	
4	S	63.30 ± 0.58	67.37 ± 0.55	68.92 ± 0.56	76.52 ± 0.54	
	F	69.37 ± 0.54	71.76 ± 0.51	72.60 ± 0.54	76.00 ± 0.52	
5	S	65.73 ± 0.71	68.77 ± 0.71	70.82 ± 0.68		68.89 ± 0.68
	F	70.73 ± 0.62	73.74 ± 0.60	74.57 ± 0.58	79.85 ± 0.81	73.14 ± 0.78
6	S					
	F	71.38 ± 0.57	73.87 ± 0.54	75.14 ± 0.57		72.75 ± 0.78
7	S	68.55 ± 0.82	70.15 ± 0.79	73.75 ± 0.86	87.65 ± 0.79	
	F	75.32 ± 1.00	74.55 ± 1.00	77.05 ± 1.05	81.41 ± 1.00	
8	S	68.02 ± 0.60	70.65 ± 0.59	74.25 ± 0.66	79.11 ± 0.98	70.00 ± 0.85
	F	72.95 ± 0.55	74.64 ± 0.52	75.92 ± 0.55	77.08 ± 0.88	73.59 ± 0.83
9	S	68.73 ± 0.63	70.70 ± 0.59	73.45 ± 0.65	75.55 ± 0.99	70.52 ± 0.90
	F	73.82 ± 0.58	73.86 ± 0.56	75.60 ± 0.61	77.44 ± 0.96	72.77 ± 0.79
10	S	69.09 ± 0.65	71.57 ± 0.62	74.12 ± 0.68	76.17 ± 1.02	70.42 ± 0.88
	F	74.95 ± 0.72	75.30 ± 0.71	75.60 ± 0.78	77.72 ± 1.13	74.75 ± 1.02
11[c]	S	68.73 ± 0.88	73.77 ± 0.88	73.45 ± 0.96		71.67 ± 0.92
	F	73.27 ± 0.80	75.15 ± 0.80	74.80 ± 0.91		74.38 ± 0.83

[a]F = fall, S = spring.

[b]Standard error.

[c]Measurements from the older group of cows.

TABLE LX

AVERAGE HEIGHT (INCHES) AT THE WITHERS OF COWS FED DIFFERENT LEVELS OF WINTER NUTRITION

Treatment		Low	Moderate	High	Very High	Very High Moderate
Year of Treatment	Season[a]					
1	F	38.25 ± 0.20[b]	38.47 ± 0.20	38.67 ± 0.20	38.37 ± 0.20	
2	S	41.10 ± 0.20	41.65 ± 0.20	42.12 ± 0.20	42.52 ± 0.20	
	F	43.71 ± 0.23	43.92 ± 0.22	44.43 ± 0.22	44.57 ± 0.22	
3	S	44.07 ± 0.24	44.82 ± 0.23	45.33 ± 0.24	46.12 ± 0.24	
	F	45.37 ± 0.25	45.91 ± 0.25	46.30 ± 0.25	46.90 ± 0.26	
4	S	45.22 ± 0.27	45.71 ± 0.26	46.38 ± 0.26	46.88 ± 0.25	
	F	46.33 ± 0.27	46.76 ± 0.25	47.06 ± 0.27	47.42 ± 0.26	
5	S	45.69 ± 0.37	46.88 ± 0.37	47.00 ± 0.37		46.86 ± 0.37
	F	46.18 ± 0.24	46.21 ± 0.23	47.00 ± 0.23	46.73 ± 0.32	47.00 ± 0.30
6	S					
	F	45.85 ± 0.24	46.08 ± 0.23	46.41 ± 0.24		46.00 ± 0.34
7	S	46.00 ± 0.37	45.17 ± 0.36	46.14 ± 0.37	47.38 ± 0.36	
	F	46.75 ± 0.39	46.09 ± 0.37	47.09 ± 0.37	47.40 ± 0.39	
8	S	45.81 ± 0.24	45.83 ± 0.23	46.37 ± 0.26	47.11 ± 0.39	45.33 ± 0.33
	F	45.70 ± 0.27	45.88 ± 0.26	46.25 ± 0.27	46.94 ± 0.46	46.00 ± 0.41
9	S	45.68 ± 0.23	45.78 ± 0.21	46.17 ± 0.23	45.44 ± 0.36	46.21 ± 0.32
	F	45.34 ± 0.27	45.65 ± 0.26	46.20 ± 0.29	45.88 ± 0.45	45.00 ± 0.37
10	S	45.66 ± 0.24	45.42 ± 0.22	45.70 ± 0.25	46.00 ± 0.37	45.29 ± 0.32
	F	45.70 ± 0.24	45.93 ± 0.23	45.90 ± 0.25	46.89 ± 0.40	45.36 ± 0.34
11[c]	S	44.73 ± 0.34	45.19 ± 0.34	45.73 ± 0.37		45.12 ± 0.35
	F	45.96 ± 0.31	46.42 ± 0.31	46.65 ± 0.35		46.58 ± 0.32

[a] F = fall, S = spring.

[b] Standard error.

[c] Measurements from the older group of cows.

TABLE LXI

AVERAGE DEPTH (INCHES) OF CHEST OF COWS FED DIFFERENT LEVELS OF WINTER NUTRITION

Treatment		Low	Moderate	High	Very High	Very High Moderate
Year of Treatment	Season[a]					
1	F	20.20 ± 0.14[b]	20.33 ± 0.14	20.47 ± 0.14	20.52 ± 0.14	
2	S	20.22 ± 0.14	21.12 ± 0.14	21.47 ± 0.14	22.83 ± 0.14	
	F	23.36 ± 0.14	23.58 ± 0.14	23.97 ± 0.14	24.25 ± 0.14	
3	S	22.11 ± 0.16	22.87 ± 0.16	23.48 ± 0.16	25.67 ± 0.17	
	F	24.26 ± 0.21	25.05 ± 0.20	25.28 ± 0.20	26.23 ± 0.21	
4	S	23.79 ± 0.18	24.63 ± 0.17	25.20 ± 0.17	27.18 ± 0.17	
	F	24.73 ± 0.20	25.52 ± 0.18	25.58 ± 0.20	26.44 ± 0.19	
5	S	24.58 ± 0.23	25.65 ± 0.23	25.86 ± 0.36		25.25 ± 0.36
	F	24.95 ± 0.19	25.23 ± 0.18	25.74 ± 0.18	26.54 ± 0.24	25.11 ± 0.24
6	S					
	F	28.20 ± 0.20	28.54 ± 0.19	28.86 ± 0.20		25.33 ± 0.27
7	S	24.50 ± 0.31	25.04 ± 0.29	25.32 ± 0.31	28.42 ± 0.29	
	F	26.95 ± 0.33	26.82 ± 0.32	27.86 ± 0.32	28.85 ± 0.33	
8	S	24.90 ± 0.23	25.23 ± 0.22	26.03 ± 0.25	28.39 ± 0.37	24.42 ± 0.32
	F	26.63 ± 0.22	26.62 ± 0.21	27.56 ± 0.22	28.00 ± 0.38	26.35 ± 0.34
9	S	25.75 ± 0.23	26.12 ± 0.22	26.92 ± 0.24	27.33 ± 0.37	25.58 ± 0.33
	F	26.61 ± 0.22	26.38 ± 0.21	27.02 ± 0.23	26.50 ± 0.37	26.25 ± 0.30
10	S	26.41 ± 0.24	26.58 ± 0.23	27.12 ± 0.25	27.94 ± 0.37	25.83 ± 0.32
	F	26.41 ± 0.22	26.70 ± 0.22	26.76 ± 0.24	26.94 ± 0.37	25.82 ± 0.32
11[c]	S	26.00 ± 0.30	27.23 ± 0.30	27.36 ± 0.32		26.88 ± 0.31
	F	26.88 ± 0.28	27.38 ± 0.28	27.35 ± 0.32		26.92 ± 0.30

[a]F = fall, S = spring.

[b]Standard error.

[c]Measurements from the older group of cows.

TABLE LXII

AVERAGE DISTANCE (INCHES) FROM CHEST FLOOR TO GROUND FOR COWS FED DIFFERENT LEVELS OF WINTER NUTRITION

Treatment Year of Treatment	Season[a]	Low	Moderate	High	Very High	Very High Moderate
1	F	18.23 ± 0.14[b]	18.22 ± 0.14	18.29 ± 0.14	17.88 ± 0.14	
2	S	20.91 ± 0.17	20.62 ± 0.16	20.69 ± 0.17	19.62 ± 0.16	
	F	20.94 ± 0.15	20.83 ± 0.14	21.10 ± 0.15	20.80 ± 0.14	
3	S	22.44 ± 0.18	22.40 ± 0.17	22.31 ± 0.18	20.40 ± 0.18	
	F	21.43 ± 0.18	21.48 ± 0.18	21.59 ± 0.18	21.19 ± 0.19	
4	S	21.90 ± 0.21	21.60 ± 0.20	21.12 ± 0.20	19.92 ± 0.20	
	F	21.27 ± 0.18	21.39 ± 0.17	21.19 ± 0.18	20.75 ± 0.17	
5	S	20.92 ± 0.25	21.12 ± 0.25	20.61 ± 0.24		21.18 ± 0.24
	F	20.95 ± 0.18	21.00 ± 0.17	21.16 ± 0.17	20.15 ± 0.23	21.46 ± 0.22
6	S					
	F	22.27 ± 0.17	22.44 ± 0.16	22.57 ± 0.17		20.62 ± 0.23
7	S	20.91 ± 0.30	20.21 ± 0.29	20.73 ± 0.30	18.96 ± 0.29	
	F	19.70 ± 0.30	19.86 ± 0.29	19.36 ± 0.29	19.05 ± 0.30	
8	S	20.98 ± 0.16	20.60 ± 0.16	20.58 ± 0.17	19.94 ± 0.26	20.79 ± 0.23
	F	19.48 ± 0.21	19.58 ± 0.19	19.04 ± 0.20	19.67 ± 0.35	19.95 ± 0.31
9	S	20.55 ± 0.20	20.42 ± 0.19	19.87 ± 0.21	18.89 ± 0.32	21.12 ± 0.29
	F	19.02 ± 0.17	19.33 ± 0.16	19.72 ± 0.18	18.81 ± 0.28	19.42 ± 0.23
10	S	19.64 ± 0.20	19.30 ± 0.19	18.98 ± 0.21	18.33 ± 0.31	20.25 ± 0.27
	F	19.20 ± 0.16	19.28 ± 0.16	19.31 ± 0.17	19.72 ± 0.27	18.91 ± 0.23
11[c]	S	18.81 ± 0.18	18.19 ± 0.18	18.36 ± 0.19		18.50 ± 0.19
	F	19.08 ± 0.15	19.15 ± 0.15	19.20 ± 0.18		19.42 ± 0.16

[a]F = fall, S = spring.

[b]Standard error.

[c]Measurements from the older group of cows.

TABLE LXIII

AVERAGE LENGTH (INCHES) OF BODY OF COWS FED DIFFERENT LEVELS OF WINTER NUTRITION

Treatment Year of Treatment	Season[a]	Low	Moderate	High	Very High	Very High Moderate
1	F	43.08 ± 0.32[b]	43.34 ± 0.32	43.79 ± 0.32	43.72 ± 0.32	
2	S	44.21 ± 0.32	46.07 ± 0.32	47.53 ± 0.32	48.37 ± 0.32	
	F	50.11 ± 0.32	50.57 ± 0.31	50.91 ± 0.32	51.48 ± 0.31	
3	S	48.76 ± 0.38	50.97 ± 0.37	51.80 ± 0.38	54.81 ± 0.39	
	F	51.94 ± 0.44	52.75 ± 0.43	53.72 ± 0.44	54.96 ± 0.45	
4	S	50.17 ± 0.51	52.73 ± 0.47	54.02 ± 0.48	55.53 ± 0.46	
	F	53.40 ± 0.39	54.93 ± 0.37	56.35 ± 0.39	56.99 ± 0.38	
5	S	52.31 ± 0.48	53.50 ± 0.48	54.39 ± 0.47		53.96 ± 0.47
	F	54.39 ± 0.38	55.31 ± 0.37	55.82 ± 0.36	58.38 ± 0.50	54.11 ± 0.48
6	S					
	F	55.17 ± 0.45	56.54 ± 0.42	55.57 ± 0.45		56.42 ± 0.61
7	S	54.50 ± 0.64	54.79 ± 0.61	55.77 ± 0.64	58.42 ± 0.61	
	F	54.50 ± 0.61	54.27 ± 0.59	55.95 ± 0.59	56.40 ± 0.61	
8	S	53.79 ± 0.40	53.58 ± 0.39	54.32 ± 0.44	56.00 ± 0.65	54.50 ± 0.56
	F	55.80 ± 0.42	55.21 ± 0.40	55.94 ± 0.41	56.56 ± 0.71	54.35 ± 0.64
9	S	54.84 ± 0.43	55.88 ± 0.41	56.20 ± 0.44	57.67 ± 0.68	53.36 ± 0.61
	F	57.14 ± 0.48	57.50 ± 0.46	56.48 ± 0.50	56.94 ± 0.79	57.38 ± 0.64
10	S	55.14 ± 0.46	55.46 ± 0.44	56.58 ± 0.48	55.67 ± 0.72	55.58 ± 0.62
	F	56.09 ± 0.49	56.26 ± 0.48	55.71 ± 0.52	56.39 ± 0.82	56.54 ± 0.70
11[c]	S	53.96 ± 0.66	54.46 ± 0.66	55.59 ± 0.72		55.04 ± 0.69
	F	55.77 ± 0.56	55.85 ± 0.56	55.40 ± 0.64		54.71 ± 0.58

[a]F = fall, S = spring.

[b]Standard error.

[c]Measurements from the older group of cows.

VITA

Joe H. Hughes, Jr.

Candidate for the Degree of

Doctor of Philosophy

Thesis: THE INFLUENCE OF WINTER NUTRITION ON THE GROWTH AND MILK PRODUCTION OF HEREFORD FEMALES AND THE BIRTH DATE AND GROWTH OF THEIR CALVES

Major Field: Animal Nutrition

Biographical:

Personal Data: Born in Spartanburg, South Carolina, October 27, 1940, the son of Joe H. and Nell I. Hughes.

Education: Graduated from James F. Byrnes High School, Duncan, South Carolina, in May, 1958. Received a Bachelor of Science degree from Clemson University with a major in Animal Husbandry in June, 1963; received the Master of Science degree from Oklahoma State University with a major in Animal Science in May, 1967.

Experience: Raised on a beef cattle farm in South Carolina. Managed a small herd of registered Angus cattle, 1958-63. Graduate Assistant in Animal Science at Oklahoma State University, 1964-68, 1970. Served as an officer in the United States Army, 1968-1970, including a tour of duty in the Republic of South Vietnam.

Professional Organizations: Member of the American Society of Animal Science, Society of Sigma Xi, Phi Kappa Phi, Alpha Zeta and Block and Bridle Club.

Date of Degree: May, 1971.