THE INFLUENCE OF POSTPARTUM NUTRITION ON COW WEIGHT AND CONDITION CHANGE, ESTRUS, CONCEPTION RATE, AND CALF PERFORMANCE OF FALL-CALVING BEEF COWS

By

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PREFACE

This study is concerned with the effect that different levels of postpartum nutrition has on reproductive performance of fall-calving beef cows. The primary objective is to determine how nutritional regimes resulting in different weight loss patterns affects return to estrus, conception rate, and calf performance in beef cows calving from September through November.

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CHAPTER I

INTRODUCTION

Approximately 30 to 40 percent of the beef cows in Oklahoma calve in the fall (September to December). Fall-calving cows vary considerably in body condition at calving due to differences in forage availability and level of protein supplementation. Many producers wean fall-born calves late (9-10 months of age) to take advantage of summer grasses and thus wean heavier calves. However, late weaning may have an adverse effect on cow condition.

Research with spring-calving cows indicates that cows on an adequate plane of nutrition prior to calving and in moderate flesh at calving have short postpartum intervals to first estrus and high conception rates. Fall-calving cows are typically in better condition going into the calving season than spring calving cows; however, little is known about the combined effects of condition at calving and postpartum level of nutrition on the reproductive performance of fall-calving cows, especially when the availability and quality of forage is decreased. While it may be possible to increase the pay weight of the calves by extending the weaning period to 9-10 months, the effect on cow condition and reproductive performance is unknown.

The objectives of this trial were: (1) to determine the effect of postpartum weight and condition changes on postpartum interval to first estrus and conception rate in beef cattle, and (2) to determine the effect of postpartum weight and condition changes of the cow on pre-weaning calf performance.

CHAPTER II

LITERATURE REVIEW

Factors Influencing Reproductive Performance

Reproductive efficiency is the most important trait in beef cattle production. The relationship between nutrition and reproductive function in beef cows has been extensively researched, with most studies being conducted with spring-calving cows. Few studies have involved fall-calving cows and little work has included the effect of postpartum nutrition on reproduction in fall-calving cows.

Several factors other than nutrition are involved in reproductive efficiency including dystocia, cow condition, suckling stimulus, milk production, breed, and age. Studies have been conducted on each of these factors, although work in some areas has been done in limited amounts.

Prepartum Nutrition

The level of prepartum nutrition is highly variable depending on the time of the year when calving occurs and the amount of available forage. Cows calving in early spring are typically exposed to a low level of prepartum nutrition unless they have received large amounts of supplemental feed during the winter. In contrast, fall-calving cows are often grazed on abundant good quality forage prior to calving.

In early work done in South Africa with both beef and dairy heifers, Joubert (1954) studied the effect of high and low nutritional planes on estrus and conception rate. Heifers on the high plane of prepartum nutrition grazed native pasture and received some supplemental feeding, whereas low level heifers only grazed the native pasture. Postpartum nutrition continued unchanged from prepartum nutrition for all females. The nutritional status was such that heifers on the high plane of nutrition did not exhibit estrus until their calves had been weaned. However, heifers on the low plane of nutrition did not begin cycling until almost a year after calving. Conception rate was not affected by plane of nutrition.

Work with mature Hereford cows indicates that the pre- and postpartum level of dietary energy influences reproductive performance (Wiltbank et al., 1962). Cows were fed two levels of prepartum energy (100% and 50% of National Research Council (NRC) suggested total digestible nutrients (TDN) requirements). Subsequently, each prepartum feeding group was divided into high and low postpartum energy levels (100% and 50% of NRC TDN requirement). The occurrence of estrus after calving was significantly influenced by feeding level. Both pre- and postpartum energy levels affected return to estrus, however, prepartum energy level was relatively more important. The response of the cows to postpartum energy level appeared to be conditioned by their pre-calving energy level. When cows were fed high pre-calving energy levels, post-calving feeding level had little effect. Cows on low prepartum energy had a marked reaction to post-calving feed level. These cows, designated as a Low-High treatment group, had an 85% cycling rate by 90 days after calving. Cows on both the low pre- and low postpartum energy levels had less than a 50% cycling rate. When the cows were fed a low energy level before calving and a high energy level after calving, postpartum interval to first estrus was significantly longer than Low-Low, High-Low, or High-High treatment groups.

Similar results were reported by Dunn et al. (1969) using two pre-calving energy levels and two or three post-calving energy levels. Hereford and Angus spring-calving, first-calf heifers were fed a Low (8.7 Mcal/day) or High (17.3 Mcal/day) level of energy prepartum. After calving, cows previously on the Low energy level were fed either a Moderate (L-M, 27.3 Mcal/day) or High (L-H, 48.2 Mcal/day) level of energy. Cows on the High pre-calving energy level received a Low (H-L, 14.2 Mcal/day), Moderate (H-M, 27.3 Mcal/day, or High (H-H, 48.2 Mcal/day) level of energy after calving.

Pregnancy rate during the first 100 days after calving was significantly affected by pre-calving energy level. By 80 days post-calving, 41% of the cows on the Low pre-calving energy level were pregnant compared to 47% of the cows on the High pre-calving energy level ($.01<P<.05$). By 100 days postpartum, comparable values were 60% and 68% ($.05<P<.10$) for Low and High pre-calving energy group, respectively. Pre-calving energy level exerted the greatest influence on occurrence of estrus during the early postpartum period. By 40 days post-calving, 25% of cows on the High pre-calving energy level had cycled compared to 6% of the Low group. The difference was more pronounced by 60 days postpartum, and this difference in return to estrus was affected up to 100 days after parturition.

Bellows and Short (1978) fed first-calf heifers a High (14.0 lbs. TDN/day) or Low (7.25 lbs. TDN/day) level of energy the last 90 days of gestation to determine the effect on postpartum reproductive performance. Heifers on the High level had a shorter postpartum interval to first estrus than heifers on the Low level (66 days vs. 87 days). The High pre-calving feed level resulted in an increased number of cows in estrus by the start of the breeding season (79% vs. 47%), and tended to increase the number of cows pregnant at weaning (78% vs. 60%) (P=.10).

Work conducted by Corah et al. (1975) to determine the effect of different levels of maternal nutrition late in gestation had conflicting results. In the first experiment, first-calf heifers were fed either 100% or 65% of the NRC (1970) recommended energy level for the last 100 days of gestation, and were fed 100% of the NRC recommended levels of protein and energy after calving. Prepartum level of energy did not significantly affect the postpartum interval to first estrus. High level heifers tended to exhibit estrus earlier, with a higher number in heat by 40 days postpartum. More heifers on the high prepartum energy level were in estrus by the start of the breeding season (74% vs. 56%) but the difference was not significant.

In experiment two, three-year-old, second-calf cows were assigned at 100 days prepartum to receive either 50% or 100% of the NRC energy level. At 30 days prepartum, 50% of the cows were assigned to 117% of the NRC requirement. All cows were fed 100% of their requirement after calving. In this study, level of prepartum nutrition had no significant effect on postpartum interval to first estrus (42 days vs. 50 days for high and low levels, respectively), or percent of cows in estrus by 40 days postpartum (48% vs. 38%).

Postpartum Nutrition

The nutritional status of cows after calving is highly variable depending on the type and amount of feed/forage available. The availability of forage is greatly affected by the date of calving. Cows that calve in early spring often have a limited amount of a rather low quality forage available for several weeks directly after calving. In contrast, cows calving in late spring typically have a very high quality forage available. The situation with fall-calving cows is reversed in that forage quality decreases later in the fall.

In an attempt to determine the effect that different levels of postpartum nutrition had on reproductive performance of mature cows, Wiltbank et al. (1962) fed either a High (16.0 lbs. TDN/day) or Low (8.0 lbs. TDN/day) energy level from calving until weaning. Prior to calving, these cows had been exposed to either a High (9.0 lbs. TDN/day) or Low (4.5 lbs. TDN/day) pre-calving energy level. Although estrus activity was influenced by pre- and postpartum energy level, prepartum level appeared to be more important. The effect of post-calving energy level appeared to be conditioned by pre-calving feeding. Cows fed the High prepartum energy level showed little response to postpartum feed level, while cows on Low pre-calving energy showed a marked response. Cows on the Low pre-calving, High post-calving nutritional regime had a significantly longer postpartum interval to first estrus (65 days and 52 days for Low-High and Low-Low groups, respectively). A comparison of conception rates indicated that postpartum nutrition may have influenced conception rates, although differences were not significant.

In a later study, Wiltbank et al. (1964) looked at five feeding levels in which prepartum energy level was held at 50% of the NRC maintenance requirement for the last 140 days of gestation, and cows were subsequently assigned to one of five postpartum TDN levels. Assigned levels of TDN/day were (1) 12.5 lbs. (75% NRC), (2) 16.5 lbs. (100% NRC),

(3) 25.0 lbs. (150% NRC), (4) 8.6 lbs. the first four or five weeks (50% NRC) and 16.4 lbs. (100% NRC), or (5) 8.6 lbs. the first four or five weeks, and then 25.2 lbs. (150% NRC). During the prepartum period of restricted intake, average condition score decreased from an initial score of 6.8 (on a scale of one = very thin to nine = very fat) to a score of 3.7 after calving. All groups, except those cows receiving 150% NRC TDN requirement lost weight for the first 28 days postpartum. Cows fed 75% TDN requirement continued to lose weight up through day 56, while all other groups either maintained their weight or gained weight. Changes in condition score typically paralleled changes in body weight. Postpartum interval to first estrus was significantly shorter in cows fed 100% of maintenance requirement than all other groups. Feeding of TDN above or below the recommended level delayed the onset of estrus. Postpartum interval to first estrus in cows fed 100% of TDN requirement averaged 49 days, compared to 73 and 72 days for cows receiving either 75% or 150% of recommended allowance, respectively. Cows fed 150% of recommended allowance had higher conception rates than the other groups, but the difference was not significant. The high energy level groups also had a shorter interval from first breeding to conception. Associated with higher conception rates in cows fed 150% of their requirement was greater ovarian activity. These cows had larger follicles and greater ovarian volume.

Hight (1968) reported findings with three-to-eight-year-old, spring-calving Angus cows fed either a High pre- and High post-calving nutrition level (H-H), High pre- and Low post-calving level (H-L), Low pre- and High post-calving level (L-H), or Low pre- and Low post-calving nutrition level (L-L). The cows on the High prepartum level gained weight up to calving, whereas cows on the Low prepartum level lost weight up to calving. All cows, regardless of post-calving nutrition level, gained weight from parturition to weaning. Subsequent pregnancy rates were 90.9%, 90.9%, 96.9%, and 55.2% for H-H, H-L, L-H, and L-L groups, respectively. These results indicate that a low level of nutrition in late gestation did not affect subsequent fertility if the cows were well fed after calving.

Dunn et al. (1969) conducted studies with two prepartum energy levels (8.7 vs. 17.3 Mcal Digestible Energy (DE)) and three levels of postpartum energy intake (14.2, 27.3, and 48.2 Mcal DE) using Hereford and Angus heifers. Pregnancy rate 120 days after calving was directly related to the level of energy fed after calving. Pregnancy rates were 87%, 72%, and 64% for the High, Moderate, and Low post-calving energy groups, respectively ($P<.05$). The influence of post-calving energy level was shown early in the breeding season. Up to 100 days after calving started, significant differences in pregnancy rate existed among all three post-calving energy groups. After 100 days (40 days of the breeding season) no significant differences existed between pregnancy rates for cows fed low and moderate postpartum energy levels (57% vs. 57% for Low and Mod groups, respectively), but cows on the High level had significantly higher pregnancy rates (76%). Postpartum energy level affected occurrence of estrus early in the postpartum period and late in the postpartum period, but in opposite ways. By 40 days post-calving, 36% of the Low energy group, 14% of the Moderate group, and 11% of the High energy group had exhibited estrus ($.05<P<.10$). In contrast, by 80 days after calving, estrus activity had reversed so that High level cows had more estrus activity than Low or Moderate level cows (90% vs. 80%

and 82%) ($.05<P<.10$). There was also a breed of cow X post-calving energy level interaction occurring at 100 and 120 days which influenced the occurrence of estrus. Hereford cows showed more response to energy level variation than Angus cows.

A relationship between weight loss near the time of breeding, plasma glucose levels, and fertility was demonstrated by McClure (1970). Over the breeding season, cows of mixed ages were fed two levels of concentrate and/or forage oats of varying stages of maturity. The cows on the lowest plane were fed to lose approximately one percent of their body weight per week. The cows fed the most immature forage oats lost weight at more than one percent per week, had blood glucose levels of 28.4 mg./100ml. and a mean first-service pregnancy rate of 16%. Cows receiving supplemental concentrate with the forage oats lost little weight, had a blood glucose level of 39.3 mg./100ml. and a mean first-service pregnancy rate of 90%. Concentrate fed alone resulted in body weight losses exceeding one percent per week, however, blood glucose levels nor pregnancy rates were depressed. When cows on least mature forages were also supplemented with concentrate, pregnancy rates improved from 33% to 90%. As protein content was considered adequate in all diets studied, it was concluded that carbohydrates were the limiting nutrient in the forage oats. Average postpartum interval to breeding was 58 days for all groups, and no significant differences in postpartum interval was found. It should also be noted that one week's nutritional treatment prior to mating affected the pregnancy rate as much as extended periods on treatment.

The influence of weight loss during the postpartum period on occurrence of estrus and ovarian function was studied in Africander and

Mashona cows (Holness and Hopley, 1978). The cows were fed to gain 12% to 14% (High) or lose 12% to 14% (Low) of fall weight by mid-breeding season. Half of the High group was placed on a restricted diet from day 25 to day 50 postpartum (HL) which was designed to supply approximately 75% of maintenance requirements. Half of the Low group was allowed access to a liberal supply of concentrates for the period from 25 to 50 days postpartum (LH). Overall, postpartum interval to first estrus was significantly shorter in High-plane than in Low-plane cows (66.4 days vs. 75.2 days). The short-term changes in feed intake (HL and LH) had a significant effect on bodyweight change, however, there was no significant effect on the occurrence of postpartum estrus (65, 68, 78, and 72 days for HH, HL, LH, and LL, respectively). Cows that lost weight from calving to first exhibition of estrus had a shorter postpartum anestrous period than cows that gained weight during the same time period. It was noted that there was a marked difference in duration of the postpartum anestrous period between breeds in this study. Two reasons for the findings that cows losing weight had shorter postpartum intervals were given. One explanation was that cows losing more weight may have been in better condition at calving. The second explanation indicated that cows losing weight were physiologically capable of mobilizing tissue reserves more rapidly, and thus could provide more nutrients for normal metabolic functions during a time of heavy demand.

Experiments were conducted with fall calving beef cows to determine the response to 175% (High), 125% (Moderate), or 90% (Low) of the estimated postpartum energy requirement (Somerville et al., 1979). By 100 days postpartum, these dietary energy levels resulted in weight losses of 8%, 16%, and 21%, respectively, of the initial postpartum weight taken approximately 12 hours after parturition. There was a non-significant trend for the pregnancy rate to decrease as plane of nutrition decreased, disregarding the month of calving. A non-significant trend was also reported for the number of cows conceiving to decrease as the month of calving advanced into the calving season, regardless of the plane of nutrition. The calving season was from September 1 to December 10, and the breeding season started on November 22 and lasted until February 28. This obviously resulted in an overlap of the two seasons by several days, allowing late calving cows much less time to return to estrus than cows calving earlier. Consequently, late calvers were often bred at first estrus, and this estrus is often not as fertile as subsequent estrus. One of the most striking features of the results was the detrimental effect of the combination of a low plane of nutrition and a late calving date.

The authors explained that the rate of weight loss at mating may be more important than the actual low body weight. This is supported by the findings that cows calving early actually weighed less during the breeding season, but their body weight loss had slowed or stopped.

Mature Hereford X Friesian and Blue-Gray cows receiving 75% of their maintenance energy prepartum requirement showed no response in conception rate when fed different levels of postpartum energy (Hodgson et al., 1980). These cows received sufficient energy to produce 4.96 lbs. (Low) or 19.8 lbs. (High) of milk daily for 6 to 14 weeks immediately postpartum, and were then grazed on a common pasture until weaning. Final calf weights, cow weights, and cow body condition scores did not differ significantly. Although there was a difference in conception rate due to breed, with Blue-Gray (Whitebred Shorthorn X Galloway) cows more fertile, there was no significant difference in conception due to postpartum energy level.

Cow Condition

The body condition of a cow at the time of parturition will vary significantly depending on management practices of the producer. The age of the cow, nutritional regime, weaning age of the previous calf, and season of calving all play important roles in influencing a cow's condition. Those studies including cow condition in their discussion have indicated that the condition of the cow at calving does influence reproductive performance. Wiltbank et al. (1962) reported that cows in good or moderate condition exhibited a higher cycling rate than thin cows during the early postpartum period. In a later paper, Wiltbank (1979) reported that at 60 days post-calving, 46% of thin cows at calving had exhibited estrus compared to 61% of the cows in moderate condition, and 91% of the cows in good condition. By 90 days after calving, 66% of the thin cows had been in heat compared to 92% and 100% for moderate and good condition, respectively, at calving. This decrease in estrus activity in thin cows resulted in a smaller percentage becoming pregnant during the breeding season.

Kunkle et al. (1979) reported that when Angus and Hereford spring-calving cows were condition scored and grouped as below average, average, or above average, differences were noted in subsequent conception rate. Respective conception rates for cows with below average, average, and above average condition scores were 56%, 63%, and 82%, respectively, during a 32-day artificial insemination (A.I.) breeding season.

Other Factors Affecting Reproduction

Dystocia, or calving difficulty, has been shown to affect rebreeding performance of cows. Laster et al. (1973) reported that cows experiencing dystocia had a longer postpartum interval to first estrus, and lower conception rates than cows needing no assistance at calving.

Suckling stimulus has been shown to have a significant effect on reproductive performance of cows. Previous studies have shown that cows suckling calves had longer postpartum intervals to first estrus than cows whose calves had been removed shortly after birth (Oxenreider, 1968; Radford et al., 1978; Saiduddin et al., 1968; Short et al., 1972; and LaVoie et al., 1982). Short et al. (1972) reported that although non-suckled cows returned to estrus significantly sooner following parturition, days to conception were similar for the two groups. Wettemann et al. (1978) found that cows nursing one calf had a significantly shorter postpartum interval to first estrus than cows nursing two calves.

Cow Body Weight and Condition Change

Beef cows normally exhibit a cyclic weight change pattern in that they tend to lose weight during late fall, winter, and early spring when forage is scarce and of low quality. The lost weight is then regained during late spring and summer when abundant, high-quality forage is available. The magnitude of the weight change will depend largely on forage quality and availability, and the level of supplementation. The level of supplementation is of special importance during the winter months when forage is typically very low in quality.

Lactational status of the female should also influence the weight change patterns. Fall-calving cows lactating through the winter months would be expected to show an accelerated weight loss in comparison to a dry cow. Similarly, a spring-calving cow would not show as rapid a gain through the early summer months as a fall-calving cow that has already had her calf weaned.

Schake and Riggs (1973) attempted to determine how changes in live weight of beef cows influence body composition. Using mature Hereford cows with an average age of 11 years, they found that percent fat, protein, and moisture in the empty body and soft tissues were not significantly altered by changes in body weight. However, a trend was observed for protein content to remain constant, and an inverse relationship between fat and moisture content was noted in the presence of significant empty body weight changes. These findings were inconsistent with some earlier work, but it was suggested that the advanced age of the cows may have had some influence on the stability of the tissues.

Lowman et al. (1979) studied the effects of different planes of nutrition on live weight and condition score. One of three planes of nutrition, either 89%, 121%, or 163% of maintenance requirements, were fed to mature fall-calving cows during the first 150 days of lactation. Changes in live weight and condition score were significantly affected by plane of nutrition. Maximum weight loss was 216 lbs., 148 lbs., and 82 lbs. for the Low, Medium, and High nutritional groups, respectively. Condition score changes reflected the trend in weight changes, and were -1.43, -0.99, and -0.45 units for Low, Medium, and High planes, respectively (condition score on a scale of one to five).

In a study previously described, Wiltbank et al. (1964) studied the effect of different postpartum energy levels on reproductive performance. Included in this data were weight changes and condition score changes during the study for the various nutritional treatments. The data indicated a trend for body weight changes to be reflected in condition score changes. However, it should be noted that in some cases where weight was maintained through the postpartum study period, condition score increased as much as .8 units (on a scale of one to nine).

Wettemann et al. (1980) studied the effect of two winter supplement levels on cow body weight change and condition score change. Cows were supplemented with cottonseed cake to maintain fall weight until the time of calving (Moderate level), or to lose 15% of their fall weight by the time of parturition (Low level). Cows fed the Moderate level of supplement actually lost 3.5% of their fall weight by calving, but maintained their condition score. Cows fed the Low level of supplement lost 14% of their fall weight, and lost 1.5 units condition (on a scale of one to nine).

Joubert (1954) studied the effects of two supplement levels during the winter months using Jersey, Friesian, Beef Shorthorns, and Afrikaner heifers. It was reported that heifers on a Low supplement level (unsupplemented) grazing winter pasture in South Africa exhibited greater weight fluctuation than heifers receiving supplement. Heifers on the Low level showed a greater weight gain in response to summer pasture than High level heifers.

Nelson et al. (1954) reported that beef cows grazing native pasture and receiving 2.57 lbs. of cottonseed meal daily lost 4 lbs. during the winter, whereas cows receiving 20.95 lbs. of prairie hay and 1.33 lbs. of cottonseed meal daily gained 48 lbs. Nelson also found that summer gain was inversely related to winter gain.

Velasco (1962) conducted research with mature Hereford cows to determine the effect of different levels of supplement fed to spring calving cows on winter native range. Cows were fed either a Low (no supplement), Medium (2 lbs. cottonseed meal), or High (2.4 lbs. of cottonseed meal plus 3.5 lbs. of milo) level of daily supplement from November to mid April. Weight loss from fall through spring calving was 34%, 22%, and 21% of fall body weight for Low, Medium, and High supplement groups, respectively.

Kothmann et al. (1968) studied the effects of three different levels of winter protein supplement and two stocking rates. Protein levels were 0, 1.5, or 3.0 lbs. of cottonseed meal per head per day, and stocking rates were 20 or 13 acres per cow. Cows receiving supplement were heavier than those cows not receiving supplement. A highly significant interaction between supplement level and stocking rate was observed. Cows receiving supplement on the lower stocking rate (20 acres per cow) showed an increase in live weight. However, cows receiving supplement while on the heavier stocking rate (13 acres per cow) showed no response in weight gain. It was concluded that energy was limiting in the diet.

Furr (1959) working with fall-calving beef cows reported weight loss of 25% to 30% of fall weight for cows receiving limited supplement on native winter range. These weight losses were reported from precalving in October until April. He concluded that weight losses this large did not affect production in mature cows, but may reduce production in first-calf heifers.

The Relationship Between Milk Production and Calf Performance

Furr and Nelson (1964) conducted a series of studies with 2, 3, or 4-year-old, fall-calving Hereford cows in an attempt to determine the effects that different levels of supplement had on cow and calf performance. Supplement levels in these studies were Low (5.0, 5.0, or 2.8 lbs. of cottonseed meal per head per day) or High (13.2, 12.5, or 14.7 lbs. of cottonseed meal/ground milo mix per head per day) for trial 1, 2, and 3, respectively. In all trials in this study, cows on the Low supplement level tended to lose more weight than cows on the High levels, however, the differences were not significant. In trials with three and four-year-old cows, milk production was significantly lower during late winter and early spring in cows on the Low supplement levels. This difference was reflected in spring weights for trial 1, and spring and weaning weights for trials 1 and 2. In the trial with two-year-old cows, milk yield tended to be lower for Low level cows, but the difference was not significant. Weaning weights in this trial were not different between treatments. For the entire study the correlations between milk production of dam and calf growth were .75 to .91, and significant in six of the nine groups compared.

Bond and Wiltbank (1970) studied the effects of different energy and protein levels on milk production and calf performance. Angus heifers were fed three levels of dietary energy and three levels of crude protein from seven months of age until 180 days after their first calf. All heifers were than placed on the same ration until they were diagnosed pregnant with their third calf. During the first lactation, heifers on the low levels of energy or protein had significantly lower milk yields than heifers on the medium or high levels of protein or energy. During the second lactation, females that had previously received the low protein diet continued to have a lower milk yield than those females fed a medium or high level of protein. In contrast, heifers initially on the low energy diet had the highest milk production during the second lactation of any of the heifers on the different energy levels. It was also noted that during the first lactation peak milk production occurred relatively later as energy or protein level increased. Protein level in the diet had no significant effect on calf growth rate, although calves from dams on the medium and high protein levels gained faster than calves from the low protein dams. Calves from cows on the low protein diet converted milk to body weight gain more efficiently than other protein groups. Calves from high and medium energy levels gained faster than calves on cows in the low energy group. Calves from cows on the low energy heifers were more efficient in converting milk to body weight gain. During the last half of the second lactation, calves from cows previously on the low energy or low protein levels gained faster than calves from cows on the high or medium energy or protein levels.

Workers have reported high correlations between milk production of the dam and calf performance to weaning (Neville, 1962; Milton et al., 1967; Reynolds et al., 1978). Correlations were found to be influenced by breed and nutritional status of the dam. Reported correlation coefficients between milk production and calf performance range from 0.42 to 0.91.

Reynolds et al. (1978) compared milk production among Angus, Brahman, Brangus, and Africander-Angus cows and determined the correlation between milk production and the growth of calves. All of the cows were placed on a similar diet. Milk yield was positively correlated with calf growth from birth to weaning. Correlation coefficients ranged from 0.42 to 0.54 for the four breeds of cows.

Neville (1962) reported high correlations between milk production of beef cows and weaning weight and growth rate of their calves. Cows were placed on three levels of nutrition during lactation, and as nutrition improved, milk yield increased. As milk production improved, the correlation between milk production and 240-day weaning weight was reduced. Within-year correlations were 0.90, 0.83, and 0.69 for the low, moderate, and high level of nutrition, respectively. Milk production was most important in influencing average daily calf gain during the first 60 days after birth (r=.74 across treatments), however, calf gain was strongly influenced by milk production during the entire pre-weaning period. It was reported that 66% of the variation in 240-day weaning weight was due to differences in milk production.

Melton et al. (1967) reported that the correlation between milk production and calf gain was significant only during the period when average calf age was 60 to 90 days (r=0.58). Overall correlation between these two traits for Angus, Charolais, and Hereford cows was 0.40. In this study, it was found that as milk production increased, efficiency of milk use by the calf decreased.

CHAPTER III

MATERIALS AND METHODS

Animals, Treatments, and Procedures

Trial I

One hundred thirty-five fall-calving Angus X Hereford cows ranging from three to six years of age and bred to Charolais or Hereford bulls were assembled at the Southwestern Livestock and Forage Research Station at Fort Reno in the summer of 1980. During the experimental period, all cows were maintained on tallgrass native pasture. The native range on the Fort Reno station, classified in excellent condition, is typified by little bluestem (Andropogon scorparius) as the predominant species and has a carrying capacity of approximately seven acres per cow-calf unit. The range forage is normally dormant from early November (first frost) to late April. Ample range forage was available at all times.

At calving (September 1, 1980 to November 5, 1980) each female was assigned to a level of postpartum nutrition within similar calving dates and age of dam to equalize these effects within treatment. Initial post-calving body weight and condition score was taken five to twelve days after parturition. The Moderate level of nutrition consisted of that amount of supplemental feed necessary for fall-calving cows to maintain their post-calving weight from parturition to the start of the breeding season. To achieve this level of postpartum nutrition, the Moderate level cows were maintained on abundant native pasture and fed seven pounds of cottonseed cake (41% crude protein) per head per day from calving to the start of the breeding season. The Low level of nutrition consisted of that amount of supplemental feed necessary to achieve a weight loss of approximately 10% from calving to the start of the breeding season. To achieve this level of postpartum nutrition, the cows were maintained on abundant native pasture and fed one-half pound of cottonseed cake (41% crude protein) per head per day until November 25, and 3½ pounds per day to December 15, 1980.

At the start of the breeding season (December 15, 1980), all cows were fed five pounds of cottonseed cake daily until March 30, 1981, and then two pounds daily until April 20, 1981. Throughout the study, all cows were fed three times per week (daily allowance X seven days ÷ three feedings). After March 1, 1981, all cows grazed common pastures through weaning.

Individual cow weights and body condition scores were taken biweekly, after a 12-hour shrink, from September 1, 1980, to February 20, 1981 (end of breeding season), and monthly from February 20, 1981, to September 1, 1981. Body weight was measured to the nearest pound, and condition score was based on a scale of one to nine (Table XI, Appendix).

All calves were weighed and identified by ear tag within 24 hours after birth. At the same time, bull calves were castrated and horned calves were treated with dehorning paste. The calves remained with their dams on native pasture until weaning and did not receive creep feed. Calf weights were obtained biweekly after a 4-hour shrink until August 7, 1981. Calf weights were measured to the nearest .5 pound. To determine the effect of weaning age on calf performance, as well as to create a 1.0 to 1.5 unit difference in cow body condition score going into the subsequent calving season, calves were weaned from their dams at 210 or 285 days of age, ± 7 days, by weaning biweekly from April 16, 1981, to August 7, 1981. Assignments to weaning age within postpartum nutrition level were made on the basis of birth date and age of dam to equalize the effect within treatment groups. The age-corrected weaning weights were adjusted for age of dam by Beef Improvement Federation Guidelines (BIF) (Hubberd, 1981) (Table XII, Appendix), and all heifer calves were corrected to a steer equivalent by multiplying by 1.05. At weaning, calves were fed a high roughage weaning ration (ad-libitum) for two weeks to reduce weight loss associated with the stress of weaning. After the two-week adjustment period, the weaned calves were placed on native pasture similar to that grazed by nursing calves and received no additional feed. All calves were implanted with Ralgro on February 3, 1981, and reimplanted on June 12, 1981.

From parturition to the start of the breeding season, surgically altered intact bulls, equipped with chin-ball markers, were placed with the cows. Marker bull activity and visual observation twice daily were used for detection of estrus. During the breeding season (December 15, 1980, to February 20, 1981), the cows were divided into four breeding groups on the basis of postpartum nutrition level. All cows were exposed to semen-tested Beefmaster bulls, which were rotated biweekly among pasture during the breeding season. Cows were observed for breeding activity twice daily, and herd bulls were equipped with chin-ball markers to assist in determination of breeding dates.

Trial II

In Trial II, fifty-four fall-calving grade Hereford cows ranging from three to eleven years of age and bred to Angus or Hereford bulls were assembled at the Lake Carl Blackwell Range Cow Research Center during the summer of 1980. The forage grazed in this study was a combination of native range, predominantly little bluestem (Andropogon scorparius), and Midland Bermudagrass (Cynodon dactylon), and has a combined carrying capacity of approximately five acres per cow-calf unit on a year-long basis. Both forages are typically dormant from mid-October to early May.

At parturition (September 17, 1980, to November 17, 1980) each cow was assigned to a level of postpartum nutrition as described in Trial I. The Moderate and Low postpartum nutrition levels had the same criteria for body weight change as in Trial I. To achieve the Moderate level of postpartum nutrition, the cows were maintained on abundant range forage and three pounds of cottonseed cake (41% crude protein) per head per day from parturition to November 17, 1980. From November 18, 1980 to December 3, 1980, the cows were maintained on range forage and six pounds of cottonseed cake per head per day. To achieve the Low level of postpartum nutrition, the cows were maintained on the range forage with no supplement until the start of the breeding season. In addition to the Moderate and Low levels, Trial II included a Moderate-Low level of postpartum nutrition which consisted of that amount of supplement necessary to maintain body weight from parturition to the start of the breeding season (December 3, 1980), and then to achieve a 20% weight loss during the breeding season (December 3, 1980, to January 27, 1981). To achieve this level of postpartum nutrition, the cows were treated similar to the

Moderate level cows prior to the start of the breeding season, and were subsequently maintained on available range forage with no supplement during the breeding season.

Cows calving after September 17, 1980, received two pounds of cottonseed cake per head per day from September 17, 1980, until parturition at which time they were assigned to the respective postpartum nutrition treatments. At the start of the breeding season (December 3, 1980), Moderate and Low level cows were fed six pounds of cottonseed cake per head per day until December 16, 1980, and were then fed five pounds of cottonseed cake until the end of the breeding season (January 27, 1981). At the end of the breeding season, all cows were fed four pounds of cottonseed cake per head per day until March 2, 1981, and five pounds per head per day until April 17, 1981, at which time supplementation was discontinued. Supplement was fed three times per week as in Trial I.

Individual cow weights and condition scores were taken on a time schedule similar to Trial I, with the final weights and condition scores taken on April 28, 1981, at the time of weaning all calves.

All calves were handled at birth in the same manner as in Trial I, and remained with their dams on pasture until weaning with no creep feed. Calf weights were taken after a 4-hour shrink on a monthly basis throughout this study. All calves were weaned on April 28, 1981, and age-corrected weaning weights were adjusted for age of dam by BIF Guidelines (Hubberd, 1981) (Table XII, Appendix), and all heifer calves were corrected to a steer equivalent by multiplying by 1.05.

Marker bulls were placed with the cows from October 1, 1980, until December 3, 1980, and estrus detection prior to the breeding season was conducted as in Trial I. During the breeding season (December 3, 1980, to January 27, 1981), all cows were exposed to fertile Hereford bulls, and breeding dates were determined as previously described in Trial I.

Statistical Analysis

The data obtained for females in both trials can be described by the following formula,

$$Y_{ijkl} = \mu + T_i + A_j + C_k + TA_{ij} + TC_{ik} + AC_{jk} + E_{ijkl}$$

where Y_{ijkl} is postpartum interval to first estrus, pregnancy status of cows (Trial II), cow weight on specific dates, cow condition score on specific dates, cow weight change or cow condition score change and where μ is a common constant, T is treatment (Trial II had an additional treatment), A is cow age, C is calving month, TA is treatment by cow age interaction, and AC is cow age by calving month interaction. The components , T_i, A_j, and C_k were treated as fixed effects of all records of treatment i, cow age j, and calving month k. Random error effect, E_{ijkl}, was specific to each observation. The treatment by cow age by calving month interaction was assumed to be zero. Estimated differences between means were obtained by method of least squares and significant differences between means were determined by the Students "t" test. The error mean square and respective degrees of freedom are presented in Tables XIII through XVI in the Appendix. In Trial I, differences in pregnancy status were tested for by Chi-Square.

The data obtained from calves can be described by the following model,

$$Y_{ijklm} = \mu + T_i + W_j + B_k + S_l + TW_{ij} + WB_{jk} + TB_{ik} + WS_{jl} + E_{ijklm}$$

where Y_{ijklm} is adjusted 210 day weight, adjusted 285 day weight, daily weight gain to 210 days of age, daily weight gain from 210 days of age to 285 days of age, or daily gain to 285 days of age and where T is treatments (Trial II had an additional treatment), W is weaning group (not applicable to Trial II), B is birth month, S is breed of sire, and the following first order interactions: TW, WB, TB, and WS. The components μ, T_i, W_j, B_k, and S_l were treated as fixed effects of all records of treatment, weaning group, birth month, and breed of sire. Random error effect, E_{ijklm}, was specific to each observation. The TS, BS, and three-way interactions and the four-way interactions were assumed to be zero. Estimated differences between means were obtained by method of least squares and significant differences between means were determined by the Student's "t" test. The error mean square and respective degrees of freedom are presented in Tables XVII and XVIII in the Appendix.

CHAPTER IV

RESULTS AND DISCUSSION

Trial I

Body Weight and Condition Change

Daily supplement levels for Moderate and Low nutrition groups are shown in Table I. Cows on the Moderate level of nutrition were able to maintain their post-calving weight and condition score up to the start of the breeding season (Table II). Although cows fed the Low level of nutrition did not lose 10% of their post-calving body weight as desired, they did lose 3.7% and 0.8 units of condition score (Table II). It should also be pointed out that, although little weight was lost, a significant loss in body condition score occurred. It was felt that the relatively small amount of weight lost by Low level cows was due to the abundant amount of fair quality forage available and unseasonably warm weather during the fall of 1980.

The use of five pounds of cottonseed meal per head per day during the breeding season (December 15, 1980 to February 20, 1981) was not sufficient to maintain body weight of either treatment group (Table II). By the end of the breeding season (February 20, 1981), cow weights and condition scores were similar for the Moderate and Low groups. Although Low level cows continued to lose weight throughout the breeding season, the increase in daily supplement level tended to improve body condition

TABLE I

LEVEL OF DAILY SUPPLEMENT FOR TRIAL I

	Treatment	
Feeding Period	Moderate	Low
Parturition to November 25	7[1]	0.5
November 26 to December 15	7	3.5
December 16 to February 20	5	5
February 21 to March 30	5	5
March 31 to April 20	2	2

[1]Amounts are in pounds per head per day

TABLE II

MEANS AND STANDARD ERRORS OF WEIGHTS, WEIGHT CHANGES AND CONDITION SCORE DATA FOR TRIAL I

Item	Treatment: Moderate	Treatment: Low
Number of Cows	50	51
Initial Weight Postcalving (lbs.)	959 ± 11.8	949 ± 11.7
Weight Start of Breeding (lbs.)	952 ± 11.6	913 ± 11.5
Weight End of Breeding (lbs.)	873 ± 11.2	853 ± 11.0
Weight at Weaning		
Calf Weaned at 210 Days	924	907
Calf Weaned at 285 Days	1075	1089
Weight Change, %		
Initial to Start of Breeding	-.7	-3.7
Initial to End of Breeding	-8.8	-9.9
End of Breeding to Weaning		
Calf Weaned at 210 Days	+5.8	+6.3
Calf Weaned at 285 Days	+23.1	+27.7
Initial to Weaning		
Calf Weaned at 210 Days	-3.6	-4.4
Calf Weaned at 285 Days	+12.1	+14.8
Condition Score		
Initial	$5.7 \pm .08$	$5.4 \pm .08$
Start of Breeding	$5.5 \pm .07$	$4.6 \pm .07$
Change to Breeding	$-.2^{a} \pm .06$	$-.8^{b} \pm .05$
End of Breeding	$5.2 \pm .06$	$4.9 \pm .06$
Change to End of Breeding	$-.6 \pm .07$	$-.5 \pm .06$
Weaning		
Calf Weaned at 210 Days	5.5	5.4
Calf Weaned at 285 Days	6.0	6.0

[a,b]Means on the same line with differing superscripts differ significantly ($P < .01$).

score (Figure 1). In support of the discrepancy between weight change and condition score change, Schake and Riggs (1973) did not find a significant relationship between body weight change and body composition change. The improvement in body condition score observed in Low level cows during this period could possibly be a result of increased forage intake and digestibility due to the improved dietary protein content of the diet. Actual weight loss during the early postpartum period may have been masked by short-term compositional changes in which water replaced body fat in adipose tissue. The drop in condition score seen in Moderate level cows was attributed to increased milk production; however, no significant differences in body condition score were noted at weaning.

When average weights and condition scores were plotted by date, disregarding the length of the postpartum period (Figure 1), weight and condition score changes were inconsistent. Weight changes were not paralleled by similar changes in condition score. It should be pointed out that up to November 11, 1980, cows were being assigned to treatment, causing the number of observations per average to vary. These illustrations show substantial variation over time, and show a greater difference in weight and condition score between treatments than means adjusted for length of postpartum period. The weight and condition scores shown in Figure 1 were the changes used in meeting the criteria for the experiment.

Figure 2 illustrates body weight and condition score changes observed after parturition. All weights and condition scores were placed on an equivalent time basis from the time of calving. This figure shows that although Moderate level cows were significantly heavier at many periods after parturition, the trends in weight change were

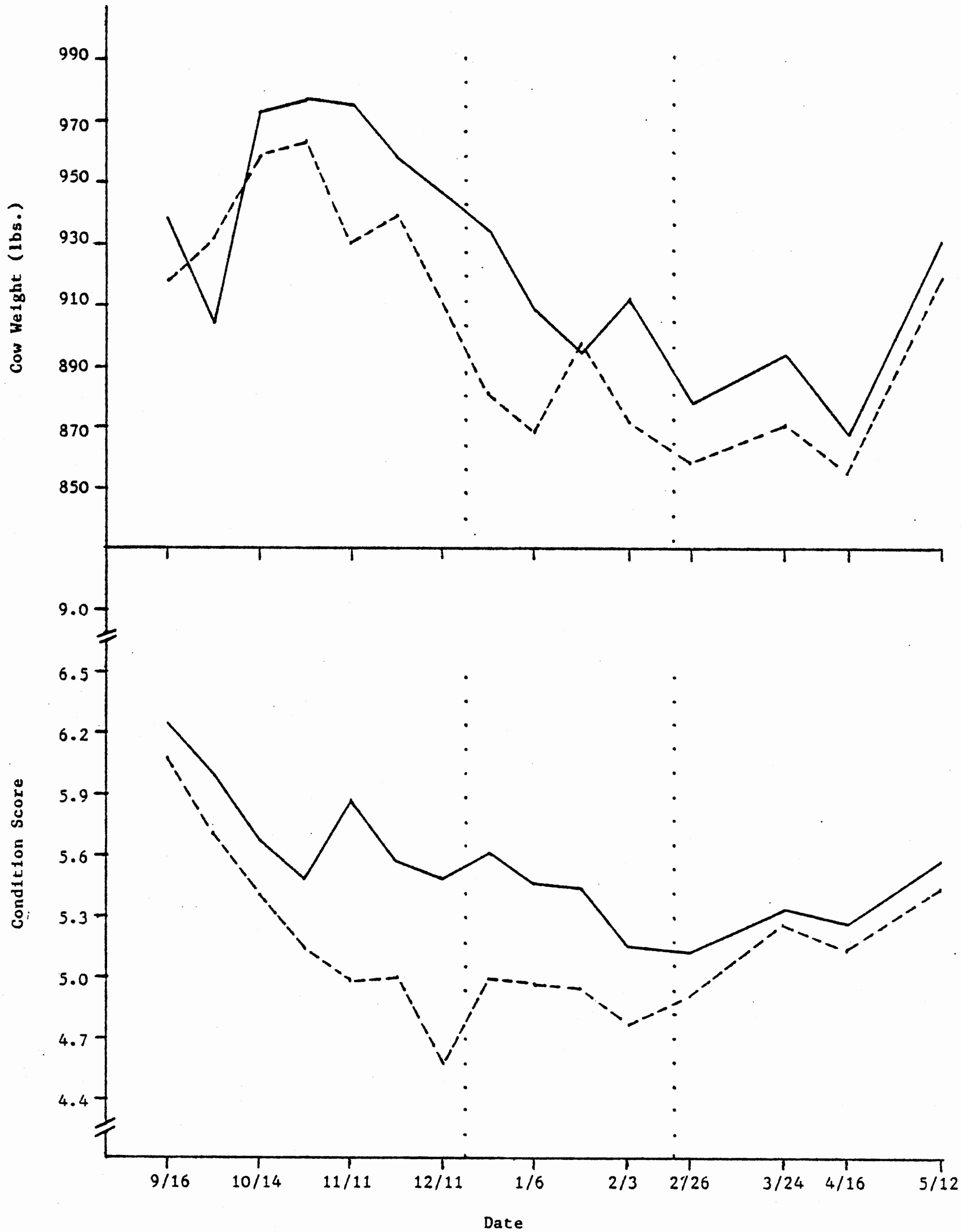

Figure 1. Mean Cow Weights and Condition Scores by Date for Moderate (——) and Low (---) Levels of Postpartum Nutrition (Trial I).

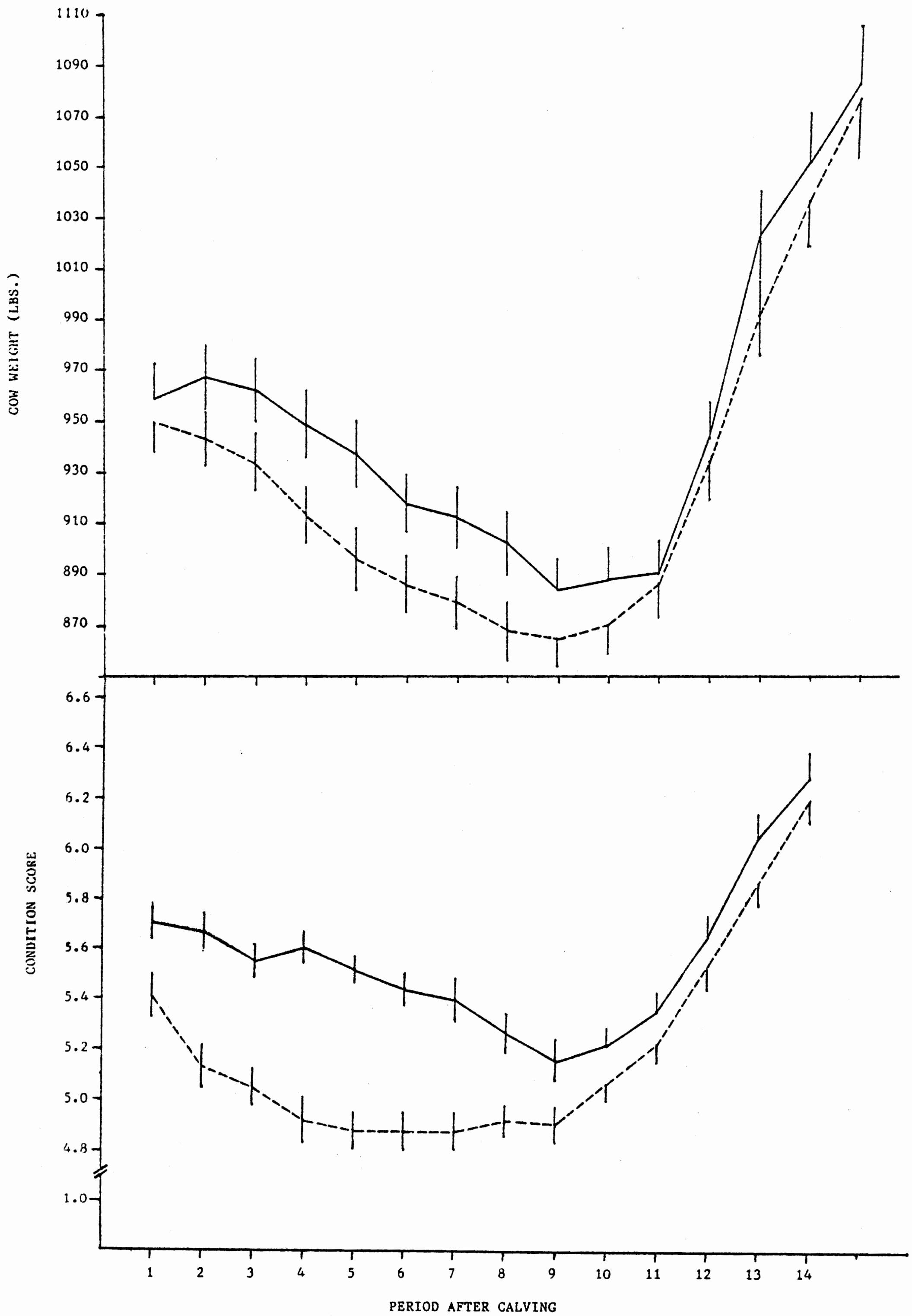

Figure 2. Mean Cow Weights and Condition Scores ± STD. ERR. for Moderate (——) and Low (---) Postpartum Nutrition Treatments (Trial I)

basically parallel. Condition score changes were slightly different in that Moderate level cows tended to maintain condition for the first four periods and then lose condition at a steady rate until a time that coincided with the growth of spring grass. In contrast, Low level cows exhibited a reduction in condition score during the first four periods and then maintained condition until the time of green grass where condition improved at a very rapid rate.

During the following summer, all cows gained a significant amount of weight and condition. Calves were weaned at 210 or 285 days of age. Two weaning ages were used to determine the effect that the dam's milk would have on calf performance during the summer, and possibly to create a 1.0 to 1.5 unit difference in condition score between the two weaning groups. This method was not effective in reducing condition score unless lactation extended into late summer. Cows weaning calves at 285 days in June or early July were in similar condition to cows that had weaned calves at 210 days in April or May. However, by late July and August, cows continuing to lactate were beginning to lose condition at a rapid rate. This would indicate that calving date may be important in a management decision when the condition of cows going into a fall-calving program is considered.

Reproductive Performance

The reproductive performance of fall calving cows was affected by the level of nutrition during the early postpartum period (Table III). Cows on the Moderate level of nutrition returned to estrus 21.7 days sooner than cows on the Low level of nutrition ($P < .01$). In addition to a shorter postpartum interval to first estrus, more Moderate level cows

TABLE III

REPRODUCTIVE PERFORMANCE FOR TRIAL I

Item	Treatment: Moderate	Treatment: Low
Number of Cows	50	51
Number Exhibiting Estrus	42	38
Days Postpartum to First Estrus[1]	$54.1^{a} \pm 3.2$	$75.8^{b} \pm 3.2$
Days Postpartum to Apparent Conception[1]	96.7 ± 2.6	97.5 ± 2.6
Number of Females Bred[2]	48^{c}	43^{d}

[1] Mean ± Standard Error

[2] Determined by rectal palpation approximately 90 days after the end of the breeding season.

[a,b] Means on the same line with different superscripts differ significantly ($P < .01$).

[c,d] Means on the same line with different superscripts differ significantly ($P < .05$).

were observed in estrus than Low level cows (42 vs. 38 cows for Moderate and Low groups, respectively). These results agree with Wiltbank et al. (1962) who reported that response to postpartum nutrition may be affected by prepartum feeding level. Although these cows had been on abundant range grass during the summer of 1980, they had gone into the summer in extremely thin condition, and the grass during that year was of questionable quality due to a very severe drought. Consequently, the cows were only in moderate condition (average condition score was 5.5) at the start of the trial. This work also agrees with Oxenreider and Wagner (1971) who reported that low levels of postpartum nutrition decreased ovarian activity. In contrast, Dunn et al. (1969) and Holness and Hopley (1978) found that cows on a high level of postpartum nutrition had longer postpartum anestrous periods than cows on a lower level of nutrition.

By the start of the breeding season, observed estrus activity noted by herdsmen was substantially less in Low level cows. However, by two or three weeks after the nutrition level was increased in Low level cows, a dramatic increase in cyclic activity was reported. This would coincide with the approximate length of time necessary for follicular development to occur. The author has had the opportunity to observe other nutritionally stressed cows react in a similar manner since this trial was conducted. Another group of thin, underfed cows began very active cycling about three weeks after the nutritional status of the group was improved.

As a result of the longer postpartum interval to first estrus and only a 65-day breeding season, conception rate was 11.7% lower in Low level cows ($P \cong .05$)(Table III). This is in agreement with Wiltbank et al. (1962), Wiltbank et al. (1964), Hight (1968), Dunn et al. (1969), and

McClure (1970) who found that conception rate was significantly affected by level of postpartum nutrition.

Two of the 50 Moderate level cows failed to rebreed during the breeding season. Both of these cows were observed in estrus during the breeding season. There was no apparent reason for these cows to be open. Both cows were in moderate to good condition, and one cow had cycled within 39 days and the other cow within 60 days of parturition. Of the eight Low level cows that were open at the end of the breeding season, four cows were never observed in estrus. The average condition score for open Low level cows at the start of the breeding season was $4.75 \pm .16$. In comparison, average condition score at the start of breeding for cows conceiving was 4.95. Average weight and condition score loss ($\pm$ standard error) for open Low level cows was -64.5 ± 13.05 pounds and $-.66 \pm .1$ units, respectively. Values for cows conceiving were -30.6 ± 5.24 and $-.83 \pm .07$ for average weight and condition score loss, respectively. All cows were in moderate condition (average condition score was 5.5) going into the calving season.

Calf Performance

The mean calf birth weight, adjusted weaning weights and weight per day of age are presented in Table IV. Postpartum nutrition level had no significant effect on adjusted weaning weight at either 210 or 285 days of age. The similar weaning weights indicate that milk production was not appreciatively affected by postpartum nutrition level. Work done by Furr and Nelson (1962), Bond and Wiltbank (1970), Neville (1962), Melton et al. (1967), and Reynolds et al. (1978) reports significant correlation (0.42 to 0.91) between dam's milk production and calf growth.

TABLE IV

MEANS AND STANDARD ERROR OF CALF PERFORMANCE DATA

	Treatment							
	Moderate				Low			
	Hereford[1]		Charolais[1]		Hereford[1]		Charolais[1]	
	210[2]	285[2]	210[2]	285[2]	210[2]	285[2]	210[2]	285[2]
Number of Calves	10	15	10	15	9	16	12	14
Adj. Birth Wt.[3]	78.1	72.2	86.9	83.6	77.9	77.9	82.8	82.6
Adj. 210 Day Wt.	379$\pm$11.9	379$\pm$9.7	462$\pm$11.9	470$\pm$9.7	358$\pm$12.5	381$\pm$9.4	437$\pm$10.9	464$\pm$10.0
Wt./Day of Age to 210 Days	1.4$\pm$0.06	1.5$\pm$0.04	1.8$\pm$0.06	1.8$\pm$0.04	1.3$\pm$0.06	1.4$\pm$0.04	1.7$\pm$0.05	1.8$\pm$0.05
Adj. 285 Day Wt.	510$\pm$14.8	582$\pm$12.1	593$\pm$14.8	658$\pm$12.1	482$\pm$15.6	568$\pm$11.7	553$\pm$13.5	655$\pm$12.5
Wt./Day of Age to 285 Days	1.5$\pm$0.05	1.8$\pm$0.04	1.8$\pm$0.05	2.0$\pm$0.04	1.4$\pm$0.05	1.7$\pm$0.04	1.6$\pm$0.04	2.0$\pm$0.04
ADG From 210 Days of Age to 285 Days of Age	1.9$\pm$0.11	2.7$\pm$0.09	1.8$\pm$0.11	2.5$\pm$0.09	1.7$\pm$0.12	2.5$\pm$0.09	1.6$\pm$0.10	2.5$\pm$0.09

[1] Breed of sire

[2] Weaning age of calves in this group

[3] All weights expressed in pounds

Thus, relating calf performance back to milk production, it was determined that milk production was not significantly different between the two nutrition groups. Furr and Nelson (1962) and Bond and Wiltbank (1970) also reported that cows on low levels of nutrition after calving had lower milk production than cows on low levels of nutrition after calving had lower milk production than cows on high levels of nutrition. However, those workers found that when nutrient status was improved in cows previously on a low nutritional regime, milk production increased to the level of cows continuously on a high plane of nutrition, and often surpassed it. This could possibly have occurred when cows on the Low treatment in this study had the daily supplement level increased to five pounds of cottonseed meal per head per day at the start of the breeding season.

Breed of sire affected ($P<.01$) birth weight and weaning weight of calves (Table IV). Charolais-sired calves were 7.43 pounds heavier at birth than Hereford-sired calves (83.96 lbs. vs. 76.53 lbs. respectively). Average adjusted 210 day weights were 86.20 pounds heavier for Charolais-sired calves over Hereford-sired calves. This significant advantage in weaning weights for calves of Charolais bulls was thought to be largely due to maximum use of heterosis, especially in conjunction with a large, growthy breed (in addition, Hereford-sired calves were 3/4 Hereford, thus reducing percent of heterosis in those calves).

The month of birth affected ($P<.01$) adjusted 210 day weight, weight per day of age to 210 days, and the average daily gain from 210 to 285 days of age (Tables V and VI). Although the number of observations were rather limited for some months, calves born late in the calving season had heavier 210 day weights. This should be expected because calves born

TABLE V

MEANS OF CALF PERFORMANCE DATA BY MONTH OF BIRTH FOR TRIAL I

Item	Hereford Sire					
Nutrition level of Dam	Mod	Mod	Low	Low	Low	Low
Weaning Age (days)	210	285	210	210	285	285
Month of Birth	Sept	Sept	Sept	Oct	Sept	Oct
Number of Calves	9	8	7	3	8	4
Birth Weight	76.6	70.7	79.1	75.2	75.4	83.0
Adj. 210 Day Weight	372	370	349	376	356	431
Wt/Day of age to 210 days	1.4	1.4	1.3	1.4	1.3	1.7
Adj. 285 Day Wt.	510	582	477	495	550	604
Wt/Day of age to 285 days	1.5	1.8	1.4	1.5	1.7	1.8
ADG from 210 days of age to 285 days of age	1.8	2.8	1.7	1.6	2.6	2.3

TABLE VI

MEANS OF CALF PERFORMANCE DATA BY MONTH OF BIRTH FOR TRIAL I

Item	Charolais Sire					
Nutrition level of Dam	Mod	Mod	Mod	Low	Low	Low
Weaning Age (days)	210	285	285	210	285	285
Month of Birth	Oct	Sept	Oct	Oct	Sept	Oct
Number of Calves	13	2	13	12	2	11
Birth Weight	87.4	81.0	84.1	81.0	82.0	82.7
Adj. 210 Day Wt.	461	409	480	458	456	445
Wt/Day of age to 210 days	1.8	1.6	1.9	1.7	1.8	1.8
Adj. 285 Day Wt.	592	631	666	562	709	638
Wt/Day of age to 285 days	1.8	1.9	2.0	1.7	2.2	2.0
ADG from 210 days of age to 285 days of age	1.7	3.0	2.5	1.6	3.4	2.4

later were allowed more time on the lush spring grass, whereas calves born early basically had milk as the primary feedstuff available during much of their pre-weaning life. Adjusted 285 day weight was not significantly affected by month of birth.

Delaying the weaning of fall-born calves to 9 to 10 months of age to take advantage of summer forage appears to be a major improvement regardless of level of postpartum nutrition of the cow. Hereford-sired calves weaned at 285 days were an average of 84.94 pounds heavier than calves weaned at 210 days and grazed on native pasture for 75 days ($P<.01$). Charolais-sired calves weaned at 285 days had a weight advantage of 80.79 pounds over earlier weaned calves.

Trial II

Body Weight and Condition Change

Daily supplement levels for Moderate, Low, and Moderate-Low (Mod-Low) nutrition groups are given in Table VII. Nutrition level had no significant effect on weight loss from parturition to the start of the breeding season. Although cows on the Low level lost 3.03% of their post-calving body weight and only 0.26 units of condition, cows on the Moderate and Mod-Low levels of nutrition were able to maintain body weight, and lost little condition during this period (Table VII). Figure 3 illustrates the weight and condition changes for Trial II. Up to November 5, the number of observations used to calculate means varied due to the fact that cows were calving and being assigned to treatment until that date. The lack of weight and condition losses in Low level cows on no supplement was attributed to an abundant quantity of forage and unseasonably warm weather during the fall of 1980.

TABLE VII

LEVEL OF DAILY SUPPLEMENT FOR TRIAL II

Feeding Period	Moderate	Low	Moderate-Low
September 17 to November 17	3[1]	0	3
November 18 to December 3	6	0	6
December 4 to December 16	6	6	0
December 17 to January 27	5	5	0
January 28 to March 2	4	4	4
March 3 to April 17	5	5	5

[1]Amounts are in pounds per head per day.

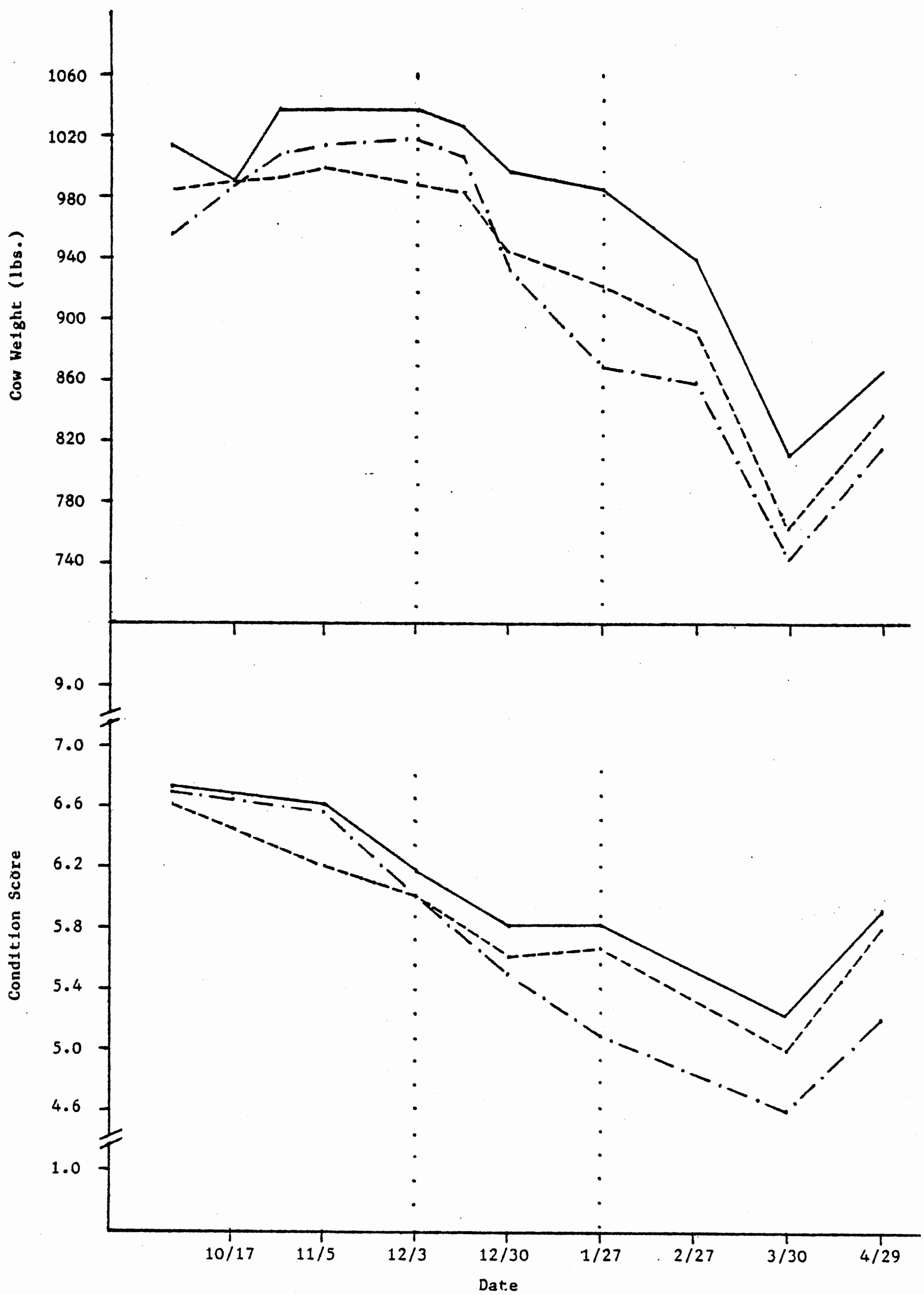

Figure 3. Mean Cow Weights and Condition Scores by Date for Moderate (——), Low (---) and Moderate-Low (-•-) Levels of Postpartum Nutrition (Trial II).

The use of five pounds of cottonseed cake per head per day was not sufficient to maintain body weight of Moderate and Low level cows through the breeding season (Table VIII). Moderate and Low level cows lost 4.8% and 6.6% of their postcalving weight and similar amounts of condition (0.39 vs. 0.31 units, respectively). Both had been in good condition (average condition score was 6.5) at the start of the breeding season. During the breeding season, Mod-Low cows lost significantly more weight than Moderate or Low groups ($P<.01$) and also lost a substantial amount of condition; however, the difference among groups was not significant ($.05<P<.10$). Mod-Low cows did not lose 20% of their post-calving weight, but did lose 14.5% and 1.05 units of condition.

Fall-calving cows should be expected to lose weight during late fall and early winter due to a large nutrient demand for milk production, and a very low quality forage as the primary energy source. Although Mod-Low cows lost a large amount of condition during the breeding season, condition scores at weaning were similar among treatment groups.

Postpartum body weight and condition score changes are illustrated in Figure 4. Weights and condition scores were plotted on a time equivalent basis, with parturition as the origin, confounding date within observation period. Figure 4 graphically depicts how weight was basically maintained for three periods regardless of treatment, and then weight was lost at a steady rate throughout the observation period. In contrast, condition score was maintained for only one period after calving for Moderate and Low level groups, and was lost throughout the trial for Mod-Low cows. Figure 4 demonstrates that weight and condition score began to improve with the growth of spring grass, similar to the situation in Trial I.

TABLE VIII

MEANS AND STANDARD ERRORS OF WEIGHTS, WEIGHT CHANGES AND CONDITION SCORE DATA FOR TRIAL II

	Treatment		
Item	Moderate	Low	Mod-Low
Number of Cows	19	17	18
Initial Weight Postcalving (lbs.)	1023±19.4	994±20.5	1008±19.9
Weight Start of Breeding (lbs.)	1017	962	999
Weight End of Breeding (lbs.)	966	895	850
Weight at Weaning (lbs.)	866	836	815
Weight Change, %			
Initial to Start of Breeding	-.6	-3.0	-.8
Initial to End of Breeding	-5.4[c]	-9.6[d]	-15.3[e]
End of Breeding to Weaning	-9.8	-5.9	-3.5
Initial to Weaning	-15.4	-15.9	-19.2
Condition Score			
Initial	6.4±0.20	6.2±0.21	6.5±0.24
Start of Breeding	6.2	5.9	6.1
Change to Breeding	-.2	-.3	-.4
End of Breeding	5.9	5.6	5.1
Change to End of Breeding	-.6±0.15	-.6±0.15	-1.4±0.18
Weaning	5.6±0.17	5.5±0.18	5.2±0.21

[c,d,e]Means on the same line with different superscripts differ significantly ($P<.05$).

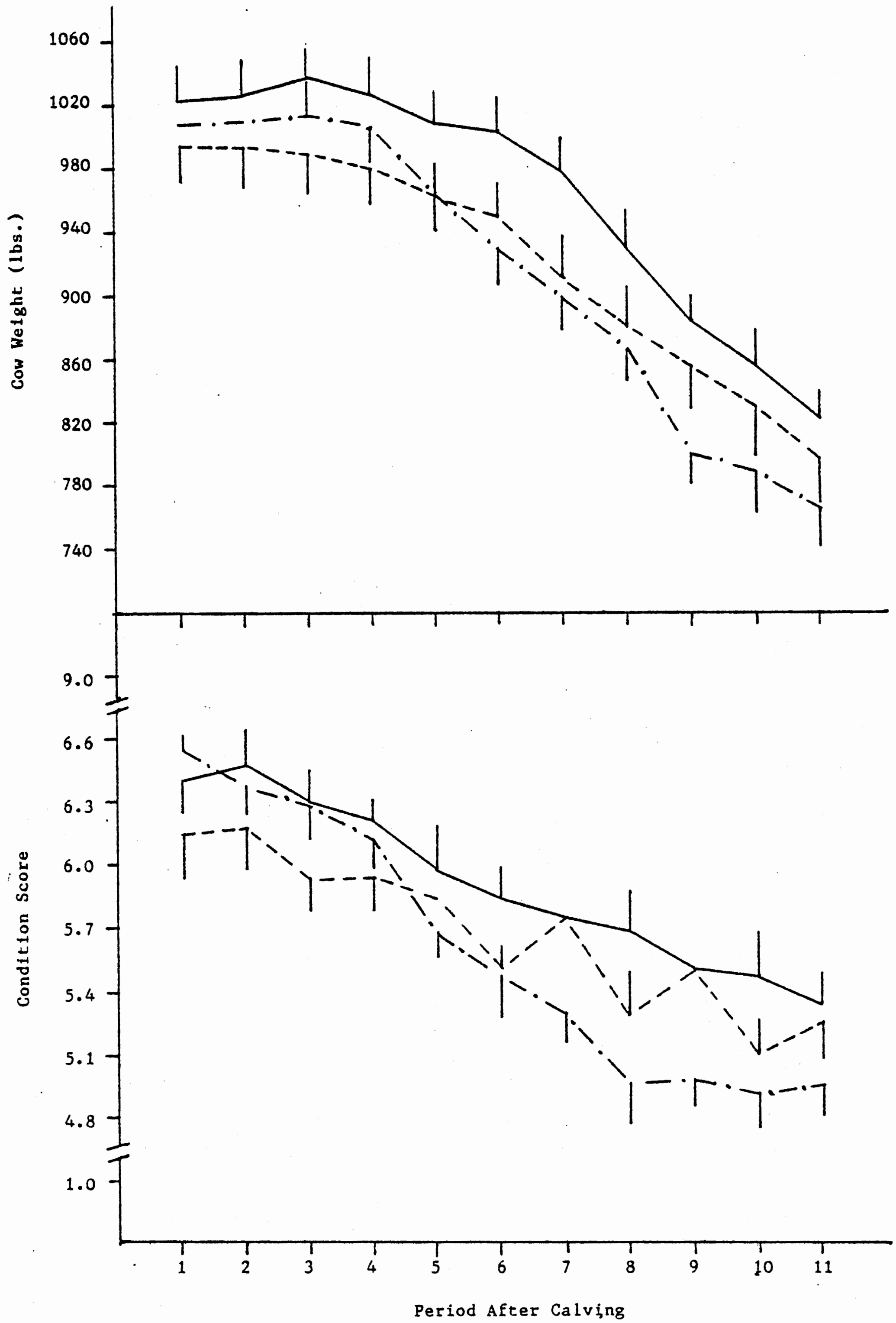

Figure 4. Mean Cow Weights and Condition Scores ± STD. ERR. for Moderate (——), Low (---) and Moderate-Low (—·—) Levels of Postpartum Nutrition (Trial II).

From the end of the breeding season until the growth of spring grass, all cows lost a substantial amount of weight but little condition (Table VIII). The loss of weight and condition score by all cows indicates that feeding adequate protein supplementation on dry winter grass will not meet the nutrient requirements of lactating beef cows. After the end of the breeding season, the suggested protein requirement had been adequately supplied, suggesting that energy was deficient in the diet.

Reproductive Performance

As in the case of Trial I, reproductive performance appeared to be affected by level of postpartum nutrition (Table IX). Although differences were not significant, Moderate and Mod-Low cows returned to estrus 18.2 and 12.0 days earlier, respectively, than cows on the Low level. This suggests that even small weight losses before breeding will affect postpartum interval to first estrus. It has been reported by Wiltbank et al. (1962) and Bellows and Short (1978) that cows on a high plane of nutrition prior to calving had shorter postpartum intervals to first estrus. The non-significant differences in postpartum interval to first estrus for the three treatment groups could be due to the good condition of the cows going into the experimental period.

In contrast to Trial I, there did not appear to be a large difference in estrus activity by the start of the breeding season. Only one cow failed to exhibit estrus in Trial II. This again is probably due to the good condition of the cows at the start of the test period, and the small amount of weight and condition score that was lost by any of the treatment groups during the early postpartum period.

TABLE IX

REPRODUCTIVE PERFORMANCE FOR TRIAL II

Item	Moderate	Treatment Low	Mod-Low
Number of Cows	19	17	18
Number Exhibiting Estrus	18	16	17
Days Postpartum to first estrus[1]	51.7$\pm$6.2	69.9$\pm$6.6	57.9$\pm$6.4
Number of Females Bred[2]	15[a]	15[a]	10[b]

[1]Means $\pm$ Standard Error

[2]Determined by rectal palpation approximately 90 days after the end of the breeding season.

[a,b]Means on the same line with different superscripts differ significantly ($P<.05$).

No significant difference in conception rate was found between Moderate and Low postpartum nutrition groups. However, conception rate for cows on the Mod-Low level of postpartum nutrition was lower than Moderate or Low level cows ($P<.05$). Conception rates were 79.0%, 88.2%, and 55.6% for Moderate, Low, and Mod-Low nutrition groups, respectively. Of the four open cows in the Moderate level, all four had been observed in estrus. All of the eight open cows in the Mod-Low nutrition group exhibited estrus prior to or during the breeding season. This finding is in disagreement with previous assumptions that if a cow would cycle and rebreed, she would conceive. Although limited by small numbers, these results suggest that if a cow is nutritionally stressed during the breeding season, conception rate may be affected regardless of cycling activity. Average weight and condition loss for Mod-Low cows during the breeding season was 147.2 pounds and 1.08 units of condition, respectively. There was no apparent reason for the four open cows in the Moderate level group of cows. These cows were in moderate to good condition during the breeding season, and had no obvious health problems.

The conception rate data for Trial II was not consistent with Trial I in that no significant difference in conception was noted between Moderate and Low levels for Trial II. This can be explained by the findings that although Low level cows in both trials were fed practically no supplement prior to the breeding season, Low level cows in Trial II lost 3.03% of their post-calving weight and only 0.26 units of condition, whereas Low level cows in Trial I only lost 3.70% of their post-calving weight but 0.8 units of condition. In addition, cows in Trial II were in better condition (approximately 0.6 units higher) at the start of the calving season.

Calf Performance

Mean calf birth weights, adjusted weaning weights, and weight per day of age are presented in Table X. Postpartum nutrition of the dam had no significant effect on calf growth to weaning ($P<.10$), although Mod-Low cows tended to have lighter calves at weaning. Furr and Nelson (1964) reported that cows on a low level of winter supplementation had significantly lower milk production than cows on a high level of supplementation. This may be reflected in the trend for Mod-Low calves to be lighter at weaning. Those cows would be expected to have a lower milk production on winter range grass when receiving no supplement. However, as no milk production determination was conducted, no definite conclusion can be reached.

Breed of sire had a significant effect on calf performance. Angus-sired calves were 4.9 pounds heavier at birth than Hereford-sired calves (79.8 lbs. vs. 74.9 lbs., respectively). At weaning, Angus-sired calves were, on average, 39.2 pounds heavier than Hereford-sired calves. The significant improvement in weaning weights of Angus-sired calves was thought to be largely due to the actions of heterosis.

In contrast to Trial I, month of calving had no significant effect on weaning weight. This appears to be a result of weaning calves prior to the onset of large quantities of spring grass. Staggering the weaning date according to age would have allowed late-born calves more access to green grass which may have resulted in heavier weaning weights. This was assumed to be the cause of the significant effect of birth month in Trial I.

TABLE X

MEANS AND STANDARD ERROR OF CALF PERFORMANCE FOR TRIAL II

	Treatment					
	Moderate[1]		Low[1]		Mod-Low[1]	
Item	Hereford[2]	Angus[2]	Hereford[2]	Angus[2]	Hereford[2]	Angus[2]
Adjusted Birth Weight[3]	75.9	81.9	73.7	78.0	75.1	79.5
Adjusted 210 Day Weight	341±11.9	382±27.4	342±12.7	375±27.4	310±13.2	354±21.2
Wt/day of age to 210 Days	1.3±0.05	1.4±0.12	1.3±0.06	1.4±0.12	1.1±0.06	1.3±0.10

[1]Nutrition level of dam.

[2]Breed of Sire

[3]All weights expressed in pounds

Conclusions

Results of this study show that postpartum weight and/or condition loss have a significant effect on reproductive performance of fall-calving beef cows. Cows that experience substantial body weight and/or condition score losses prior to the breeding season will exhibit significantly longer postpartum anestrous periods. In addition, these data indicate that cows in thin to moderate condition at calving will have reduced conception rates if large amounts of weight or condition are lost before breeding. Nutrient deficiencies during the breeding season will result in a very significant reduction in conception rate. In this study, cows losing an average of 14% of their post-calving weight during the breeding season had a 50% conception rate. In comparison, cows losing 1.0% or 3.0% of their post-calving weight had conception rates of 78% and 88%, respectively. These results indicate that a nutritional stress which results in substantial weight or condition losses during the postpartum period will significantly reduce reproductive performance of fall-calving beef cows.

Postpartum weight or condition loss does not appear to permanently reduce milk production in beef cows. No significant difference in weaning weight was noted among postpartum nutrition treatments, although cows losing 14% of their post-calving weight during the breeding season tended to have lighter calves at weaning. Using calf performance as a measure of milk production, the results indicate that if milk production is reduced during times of nutritional stress, an improvement in nutritional status will cause milk production to return to normal levels. In this study, no definite conclusion can be reached in regard to milk production due to the fact that no milk production determination was conducted.

CHAPTER V

SUMMARY

Two trials were conducted with fall-calving beef cows to determine the effect that different levels of postpartum nutrition had on weight and condition change, postpartum estrus activity, conception rate and calf performance. In Trial I, 101 Angus X Hereford cows ranging from three to six years of age, and bred to Hereford or Charolais bulls, were assigned to either a Moderate (supplemented to maintain post-calving body weight) or Low (allowed to lose 10% of their post-calving body weight by the start of the breeding season) level of postpartum nutrition. Moderate level cows were fed seven pounds of cottonseed cake (41% crude protein) per head per day from parturition to the start of the breeding season (December 15, 1980). Low level cows received 0.5 pounds of cottonseed cake per head per day from parturition to November 25, 1980, and 3.5 pounds of cottonseed cake per head per day from November 26 to the start of the breeding season. All cows were fed five pounds of cottonseed cake per head per day from the start of the breeding season (December 15, 1980) to March 30, 1981, and two pounds per head per day from April 1 to April 20. Calves were weaned at 210 or 285 days of age, and weights were adjusted for age of dam, and age and sex of calf.

Moderate level cows were able to maintain body weight until the start of the breeding season with only a slight loss of condition. Due to abundant forage and unseasonably warm weather, low level cows lost only 3.70% of post-calving weight, but condition score was reduced by 0.8 units (on a scale of one to nine). After the start of the breeding season, the use of five pounds of daily supplement was not sufficient to maintain the weight of either treatment group. However, the increase in supplement level at the start of the breeding season tended to improve the body condition score of Low level cows. No difference in body condition score between treatments was noted at weaning.

Postpartum nutrition level had a significant effect on postpartum interval to first estrus and conception rate during the breeding season. Average postpartum interval was 21.7 days shorter for cows on the Moderate level than for cows on the Low level of nutrition ($P<.01$). In addition, conception rate was 11.7% higher for cows on the Moderate level ($P\lesseqqgtr .05$).

Postpartum nutrition level of the dam had no significant effect on calf performance. Calves from Charolais sires were significantly heavier at weaning than Hereford-sired calves ($P<.01$), and adjusted 285 day weights were significantly heavier for calves weaned at 285 days of age than calves weaned at 210 days of age and grazed on native range for 75 days.

In Trial II, using Hereford cows from three to ten years of age and bred to Hereford or Angus bulls, Moderate and Low levels of postpartum nutrition were similar to those in Trial I. In addition, Trial II included a treatment in which cows were fed to maintain post-calving weight until the start of the breeding season, and then were to lose 20% of post-calving weight during the breeding season. All calves were weaned on April 28, 1981, and weights were adjusted for age of dam and age and sex of calf.

Regardless of postpartum nutrition, all cows basically maintained weight and condition score until the start of the breeding season (December 3, 1980, to January 27, 1981). Weight changes from parturition to the start of the breeding season were -0.6, -3.0, and -0.8% for Moderate, Low and Mod-Low nutrition groups, respectively, and condition score changes were -0.17, -0.26, and -0.38 units for Moderate, Low and Mod-Low groups, respectively. During the breeding season, all cows lost weight and condition, however, Moderate-Low level cows did lose significantly more weight and condition. Weight losses were 4.8, 6.6, and 14.5% and condition score losses were -0.39, -0.3, and -1.05 units for Moderate, Low and Mod-Low groups, respectively.

Reproductive performance was affected by postpartum level of nutrition. Although postpartum interval to first estrus was not significantly different among the three nutrition groups (52, 70, and 58 days for Moderate, Low, and Mod-Low groups, respectively), there was a trend for Low level cows to have a longer postpartum interval. Moderate and Low nutrition groups had significantly higher conception rates than the Moderate-Low group (78.95%, 88.24%, and 50.00%, respectively).

As in Trial I, level of postpartum nutrition of the dam had no significant effect on calf performance ($P > .10$), although cows in the Mod-Low group tended to wean lighter calves. Breed of sire did affect calf growth, with Angus-sired calves 39.22 pounds heavier than Hereford-sired calves at 210 days of age. Age adjusted 210 day weaning weights were 341, 342 and 310 lbs. for Hereford-sired calves on Moderate, Low and Mod-Low cows, respectively, and 382, 374 and 354 lbs. for Angus-sired calves on Moderate, Low and Mod-Low cows, respectively.

Data from these trials show that substantial losses of weight and/or condition score between parturition and the start of the breeding season will extend the postpartum interval to first estrus, and will reduce the conception rate if cows are in thin to moderate condition at calving. These data also show that significant weight and condition loss during the breeding season will cause a very significant reduction in conception rate. Losses in cow weight and/or condition score from calving to the breeding season were not found to have a significant effect on weaning weight of calves, however, there was a tendency for cows losing significant amounts of weight and condition during the breeding season to wean lighter calves.

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APPENDIX

TABLE XI

SYSTEM OF BODY CONDITION SCORING (BCS) FOR BEEF CATTLE

Group	BCS	Description
Thin Condition	1	EMACIATED - Cow is extremely emaciated with no detectable fat over spinous processes, transverse processes, hip bones or ribs. Tail-head and ribs project quite prominently.
	2	POOR - Cow still appears somewhat emaciated but tail-head and ribs are less prominent. Individual spinous processes are still rather sharp to the touch but some tissue cover exists along spine.
	3	THIN - Ribs are still individually identifiable but not quite as sharp to the touch. There is obvious palpable fat along spine and over tail-head with some tissue cover over dorsal portion of ribs.
Borderline Condition	4	BORDERLINE - Individual ribs are no longer visually obvious. The spinous processes can be identified individually on palpation but feel rounded rather than sharp. Some fat cover over ribs, transverse processes and hip bones.
Optimum Moderate Condtion	5	MODERATE - Cow has generally good overall appearance. Upon palpation, fat cover over ribs feel spongy and areas on either side of tail-head now have palpable fat cover.
	6	HIGH MODERATE - Firm pressure now needs to be applied to feel spinous processes. A high degree of fat cover is palpable over ribs and around tail-head.
	7	GOOD - Cow appears fleshy and obviously carries considerable fat. Very spongy fat cover over ribs and over and around tailhead. In fact "rounds" or "pones" beginning to be obvious. Some fat around vulva and in crotch.
Fat Condition	8	FAT - Cow very fleshy and over conditioned. Spinous processes almost impossible to palpate. Cow has large fat deposits over ribs, around tail-head and below vulva. "Rounds" or "pones" are obvious.
	9	EXTREMELY FAT - Cow obviously extremely wasty and patchy and looks blocky. Tail head and hips buried in fatty tissue and "rounds" or "pones" of fat are protruding. Bone structure no longer visable and barely palpable. Animal's mobility may even be impaired by large fatty deposits.

TABLE XII

BEEF ADJUSTMENT FACTORS

Birth weight (BW)
sex adjustment
adjustment of females to a male basis
multiply female birth weight by 1.07

age of dam adjustment
adjustment to mature dam basis

age of dam	additive adjustment (lbs.)
2	+8
3	+5
4	+2
5–10	+0
11+	+3

Weaning weight (ww)
adjustment to 205-day basis

$$\text{205-day weight} = \frac{\text{actual ww} - \text{BW}}{\text{age in days}} \times 205 + \text{BW}$$

age of dam adjustments (add to 205-day weight)

	additive adjustment	
age of dam	male calves	female calves
2	+60	+54
3	+40	+36
4	+20	+18
5–10	+0	+0
11+	+20	+18

TABLE XIII

ERROR MEAN SQUARE (EMS) AND RESPECTIVE DEGREES OF FREEDOM (df) FOR WEIGHTS, WEIGHT CHANGES, AND CONDITION SCORE DATA (TRIAL I)

Trait	df	EMS
Initial Post-calving Weight	84	7016.063
Weight Change		
Initial to Start of Breeding	84	1024.986
Initial to End of Breeding	80	1150.556
Initial Post-calving Condition	84	0.309
Condition Change		
Initial to Start of Breeding	84	0.151
Initial to End of Breeding	80	0.216

TABLE XIV

ERROR MEAN SQUARE (EMS) AND RESPECTIVE DEGREES OF FREEDOM (df) FOR REPRODUCTIVE PERFORMANCE DATA (TRIAL I)

Trait	df	EMS
Postpartum Interval to First Estrus	65	509.415
Postpartum Interval to Apparent Conception	69	347.760
Conception Rate	65	0.085

TABLE XV

ERROR MEAN SQUARES (EMS) FOR WEIGHTS, WEIGHT CHANGES AND CONDITION SCORE DATA (TRIAL II)

Trait	df	EMS
Initial Post-calving Weight	30	7160.808
Weight Change		
Initial to Start of Breeding	30	1675.311
Initial to End of Breeding	30	2196.585
Initial Post-calving Condition	9	0.388
Condition Change		
Initial to Start of Breeding	9	0.301
Initial to End of Breeding	9	0.218

TABLE XVI

ERROR MEAN SQUARE (EMS) AND RESPECTIVE DEGREES OF FREEDOM (df) FOR REPRODUCTIVE PERFORMANCE DATA (TRIAL II)

Trait	df	EMS
Postpartum Interval to First Estrus	28	702.725
Conception Rate	30	0.173

TABLE XVII

ERROR MEAN SQUARE (EMS) AND RESPECTIVE DEGREES OF FREEDOM (df) FOR CALF PERFORMANCE DATA (TRIAL I)

Trait	df	EMS
Adjusted 210 Day Weight	88	1414.709
Weight/day of Age to 210 Days of Age	88	0.031
Adjusted 285 Day Weight	88	2188.051
Weight/day of Age to 285 Days of age	88	0.025
ADG from 210 Days of Age to 285 Days of Age	88	0.123

TABLE XVIII

ERROR MEAN SQUARE (EMS) AND RESPECTIVE
DEGREES OF FREEDOM (df) FOR
CALF PERFORMANCE DATA
(TRIAL II)

Trait	df	EMS
Adjusted 210 Day Weight	44	2339.204
Weight/day of Age to 210 Days of Age	44	0.046

VITA

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Master of Science

Thesis: THE INFLUENCE OF POSTPARTUM NUTRITION ON COW WEIGHT AND CONDITION CHANGE, ESTRUS, CONCEPTION RATE, AND CALF PERFORMANCE OF FALL-CALVING BEEF COWS

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