EFFECTS OF POSTPARTUM WEIGHT AND BODY CONDITION LOSS ON THE PERFORMANCE OF FALL CALVING BEEF COWS

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PREFACE

This study is concerned with the effects of various postpartum nutritional levels on the performance of fall calving beef cows. The primary purpose of this study is to determine how different nutritional regimes, as reflected by body weight and condition changes, effects the reproductive performance of fall calving cows, and their calves' pre-weaning weight gains.

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CHAPTER I

INTRODUCTION

It is estimated that 30-35% of all beef cows in Oklahoma calve in the fall (Sept.-Dec.). Fall calving cows are usually in good body condition at parturition due to the quality and quantity of forage during summer. However, most fall calving cows lose weight after calving and during the breeding season. Cows that lose weight after calving tend to have longer postpartum intervals from calving to first estrus than cows that gain weight. To maintain a 365 day calving interval a cow must be rebred by 85 days after calving. The cost of high supplemental feed required for lactating cows on winter range can make fall calving expensive. Insight into the timing of the allocation of feed resources and the nutritional demands of the cow herd for maximum reproductive performance would boost the over-all efficiency of the cow herd enterprise. The objective of this research was to determine the effects of weight and body condition loss before and during the breeding season on the reproductive performance of fall calving cows, and the pre-weaning performance of their calves.

CHAPTER II

REVIEW OF LITERATURE

Reproductive efficiency has been termed the single most economically important trait in beef cows. Considerable research has been done in the area of nutrition and it's affect on beef cow reproduction, however, most of the work has been conducted with spring calving herds and on prepartum nutrition. There have been only a limited number of studies conducted to determine postpartum nutritional effects on reproduction in the fall calving cow. Although most of these studies demonstrate the general relationships between cow weight loss and rebreeding performance, more precise data about timing of nutrient intake before and during the breeding season is needed in order to more efficiently allocate winter feed resources.

Other factors which effect reproductive efficiency in beef cattle are cow condition, suckling stimulus, milk production, dystocia, breed, age of cow and date of calving. Some of these factors have been extensively studied, however, only limited work has been conducted in other areas. The effect of cold stress on nutrient requirements for maintenance and lactation is of great concern in fall calving herds because fall calving cows are frequently subject to cold stress during breeding. Validation of condition score as an accurate method for estimating cow energy status would greatly simplify management of fall calving cows during the winter.

Prepartum Nutrition

The cow herd's prepartum level of nutrition is dependent upon forage quality, availability and level of supplementation, which in turn is related to the time of year at which calving occurs. The nutritional status at and before calving for spring calving cows is generally quite low unless winter supplement has been provided. On the other hand, fall calving herds generally calve in good condition due to the forage available in the summer and early fall.

Wiltbank et al. (1962) used 83 pregnant spring calving Hereford cows in an experiment with two prepartum energy levels; high (9 lb. TDN/head/day/) and low (4.5 lb. TDN/head/day). After calving, treatment groups were divided into high (16 lb. TDN/head/day) and low (8 lb. TDN/head/day) to constitute high-high, high-low, low-high, and low-low treatments. Prior to calving, cows in the high energy group gained weight and maintained their condition scores.

Pregnancy rates were 95, 77, 95 and 20 percent for cows fed the H-H, H-L, L-H and L-L rations, respectively. This was mainly attributed to the number of cows cycling. Mean intervals from calving to first estrus were 48, 43, 65 and 52 days for the H-H, H-L, L-H and L-L groups, respectively. The authors suggested the response to energy level after calving was influenced by the pre-calving energy level. Cows on the high energy level before calving had fewer days to first estrus and a higher percentage of cows cycling by 90 days post-calving.

Corah et al. (1975) conducted two experiments to determine the affect of maternal nutrition during the last 100 days of gestation on cow reproductive performance and pre-weaning calf performance. In experiment one, 59 first-calf Hereford heifers were assigned to one of two dietary energy levels (high, 100% and low, 65% of the N.R.C. recommended levels). Prepartum nutrition did not significantly effect the average number of days for heifers to reach their first postpartum estrus. By breeding season, 74% of the adequately fed heifers had shown estrus compared to 56% of the restricted heifers. All adequately fed heifers had shown estrus by the end of the breeding season, where as 7% of the low group did not.

Prepartum and postpartum energy influence on reproduction was studied in 203 spring calving Angus and Hereford yearling heifers (Dunn et al., 1969). Heifers were assigned to two pre-calving energy levels (low, 8.7 or high, 17.3 Mcal DE/head/day). Post-calving, high energy level heifers were assigned to either a high-low, 14.2, high-moderate, 27.3 or high-high, 48.2 Mcal DE/head/day. Low energy level heifers were assigned to low-moderate, 27.3 or low-high, 48.2 Mcal DE/head/ day.

Pre-calving energy intake affected the pregnancy rate during the first 100 days after calving. Sixty percent of the heifers on the low energy intake were pregnant by 100 days compared to 68% of the high group ($P<0.05$). Pre-calving energy level exerted the greatest influence in the early postpartum period. Forty days after calving 25% of the high group had shown estrus compared to only 6% of the low group ($P<0.05$). This difference persisted until 80 days post-calving, however, after 100 days post-calving the pre-calving energy level was no longer an important variable.

Bellows and Short (1978) fed Angus x Hereford yearling heifers one of two pre-calving energy levels during the last 90 days of gestation; low, 3.4 or high, 6.3 kg TDN/head/day. Days from calving to first estrus were reduced in heifers fed high energy diets (66 vs 87) ($P<0.01$). The high group had more heifers exhibiting estrus before the breeding season (79% vs 47%), and more heifers pregnant at weaning (87% vs 60%). In a second experiment using two pre-calving and two post-calving energy levels similar results were obtained.

Joubert (1954) conducted an experiment using 28 heifers of 2 beef breeds and 2 dairy breeds in South Africa. Heifers were placed on either a low or high plane of nutrition during the winter months up to calving. After calving, low plane heifers were fed the same diet as the high group. High plane heifers exhibited estrus only after weaning their calves and low plane individuals required almost a year to regain depleted body reserves before sexual activity was restored. The author attributed this to the very poor nutritional conditions in that region of South Africa. The low nutritional plane caused no detrimental influence on the number of services per conception. The author noted that due to limited numbers and the fact that the same bull was used for all animals of any particular breed, the validity of any conclusions would be questionable. The author also suggested that with the approach of favorable nutritional conditions, animals in a low body condition would first restore depleted body tissues before sexual activity would return to normal.

Eighty spring calving Hereford cows were maintained in two groups under range conditions (Wettemann et al., 1980). Cows were supplemented to lose either 3.5% or 14% of their November weight by calving. Body condition score was 6.0 (1=very thin, 9=very fat) for both groups on November 15, however, by March the difference between the two groups was 1.5 (6.0 vs 4.5). By 80 days post-calving 20% more cows on the moderate level of nutrition were observed in estrus. Pregnancy rate for the moderate cows was 85% compared to only 70.6% for cows on the low plane of nutrition.

Turman et at. (1964) fed 80 spring calving heifers to lose 20 or 5 percent of their fall weight by calving. Heifers which lost only 5 percent of their fall weight had significantly higher conception rates and shorter postpartum intervals. After calving, these groups were further divided into low and high post-calving treatments. When low level per-calving heifers were fed higher nutritional levels after calving, conception rates were greatly increased (75% vs 53%).

Rasby (1983) found that concentrations of glucose and protein in plasma, and packed cell volume in blood was reduced in cows on a low prepartum nutritional regime. Fewer cows on restricted levels of nutrition exhibited estrus by 85 days after calving, and fewer cows became pregnant during the breeding season. This indicated the prepartum nutritional influence on these parameters may alter endocrine functions during the post-calving period.

Postpartum Nutrition

Cows which calve early in the fall generally have better quality forage available than cows which calve later. In spring calving systems, this trend is usually reversed due to the poor quality of forage in early spring compared to late spring. Thus, it is evident that the date of calving markedly influences the plane of nutrition after calving. It should also be noted that as lactation progresses in fall calving herds, forage quality decreases, where as, the reverse is true in spring calving herds.

Dunn et al. (1969) used Angus and Hereford heifers to conduct studies with two prepartum energy levels (high, 17.3 and low, 8.7 Mcal DE/head/day) and three postpartum energy levels (high, 48.2; moderate, 27.3 and low, 14.2 Mcal DE/head/day). No heifers were allocated to a low-low treatment. Weight changes from calving to 120 days post-calving were: 18, 98, 60, 35 and -28 kg for the L-H, H-H, L-M, H-M and H-L energy levels, respectively ($P<0.01$).

Pregnancy rates 120 days post-calving were directly related to post-calving energy levels. Results were 87, 72 and 64 percent for the high, moderate and low groups, respectively ($P<0.01$). Post-calving energy level affected the occurrence of estrus both early and late in the postpartum period. Forty days after calving 36% of the low energy group had exhibited estrus compared to only 14% and 11% of the moderate and high groups, respectively ($0.05<P<0.01$). This was due to the very high cycling rate of high prepartum heifers that were allotted to the low postpartum treatment. By 120 days after calving this trend had reversed with 100% of the high heifers exhibiting estrus and 96 and 81 percent of the moderate and low heifers, respectively.

At 100 days post-calving there was a breed x post-calving energy level interaction ($0.05<P<0.01$). This interaction occurred because the percentage of Hereford cows which exhibited estrus by 100 days postpartum increased directly as the energy level increased (70, 90 and 100 percent for low, moderate and high, respectively). Percentages of Angus cows in estrus were not affected by the energy level (91, 94 and 95 percent for the low, moderate and high, respectively).

The differences in occurrence of estrus between the Hereford and Angus cows supported evidence that reproductive performance of certain breeds differ under a given environment.

Wiltbank et al. (1962) used two pre-calving energy levels (high, 9 lb. and low, 4.5 lb. TDN/head/day) and two post-calving energy levels (high, 16 lb. and low, 8 lb. TDN/head/day). Estrus activity was influenced by both pre- and postpartum energy levels. However, the authors suggested that the prepartum energy level appeared to be more important. Cows fed the high pre-calving diet showed little response to postpartum energy levels. Cows fed the L-H diet had a significantly higher pregnancy rate (95% vs 20%) than cows in the L-L group. Cows being fed the L-L diet exhibited fewer days to first estrus than the L-H treatment (52 vs 65).

Somerville et al. (1979) in a series of experiments used 76 Blue-Gray and Hereford x British Friesian fall calving beef cows to determine the effect of postpartum nutrition on reproductive performance. Cows calved in good condition and were fed either 175% (high), 125% (moderate) or 90% (low) of their estimated energy requirement for maintenance for the first six months of lactation. At 100 days postpartum, cows had lost 8, 16 and 21 percent of their first weight after calving for the high, moderate and low planes, respectively.

Reproductive performance of cows in the high and moderate groups was satisfactory, but 18% of the low cows did not conceive during the 100 day breeding season. Cows on the low plane of nutrition which calved early had a higher conception rate at first and second service than cows which calved late. The authors suggested the rate of live weight loss experienced by a cow up to breeding has more effect on fertility than absolute live weight at breeding.

Mc Clure (1970) fed dairy cows, of mixed ages, two levels of concentrate and/or forage oats of varying stages of maturity. Cows on the lowest plane of nutrition were fed to lose one percent of their body weight per week at about the time of mating. Cows fed the most immature forage oats lost more than 1% of their body weight per week and had a mean first service pregnancy rate of 16%. Also, blood glucose levels were measured at 28.4 mg/100 ml. When these cows were supplemented with concentrate, pregnancy rates improved from 33% to 90%. Cows fed supplement with forage oats lost little weight, had a mean first service pregnancy rate of 90% and blood glucose levels of 39.3 mg/100 ml. Cows supplemented with concentrate only lost more than 1% of their body weight per week, but neither blood glucose levels or pregnancy rates were depressed. The author suggested that infertility was not due to weight change. No significant differences in postpartum interval were found.

Hight (1968) placed 140, 3 to 8 year old, Angus cows on either a low or high plane of nutrition during late gestation. After calving each group was then divided to form either a H-H, H-L, L-H or L-L group. High plane (pre-calving) cows gained 58 pounds and low plane cows lost 80 pounds. Between calving and weaning cows gained from 1.46 to .05 lb./day.

The percentage of non-pregnant cows at 200 days after calving was 9.1, 9.1, 3.1 and 44.8 for the H-H, H-L, L-H and L-L groups, respectively. The author concluded that a low plane of nutrition in late pregnancy did not affect pregnancy rate if cows were well fed after calving. Total effect of pre-calving nutrition on calf weaning weight was similar to that of the post-calving plane of nutrition.

Holness and Hopley (1978) fed 160 Africander and Mashona beef cows to either gain 12% to 14% (high) or lose 12% to 14% (low) of their autumn peak live weight by mid-breeding season. Half the cows in each group were subjected to an increase (L-H) or decrease (H-L) in nutrient intake from day 25 to day 50 postpartum. Live weight changes followed the predicted pattern, but short term feed intake had no significant effect on live weight change.

Days to first estrus occurred significantly earlier in the high plane cows (66 vs 75) ($P<0.05$), however, short term changes in nutritional intake had no apparent effect. Within both the high and low groups, cows that lost weight from parturition to first estrus showed signs of estrus significantly earlier than cows which gained weight. The authors stated that cows which lost weight were able to mobilize tissue reserves more rapidly and were thus better equipped to provide for normal metabolic function during the time of heavy demand for available nutrients.

Wiltbank et al. (1964) used 69 mature Hereford spring calving cows to determine the effect of postpartum energy level on reproductive performance. Cows were allotted to one of five energy levels: I, 12.5 lb. TDN (75%); II, 16.5 lb. TDN (100%); III, 25 lb. TDN (150%); IV, 8.6 lb. TDN (50%) the first 4 to 5 weeks post-calving and 16.4 lb. TDN (100%) thereafter; and V, 8.6 lb. TDN (50%) the first 4 to 5 weeks post-calving and 25.2 lb. TDN (150%) thereafter.

Cows fed 100% of their TDN requirement averaged 49 days from calving to first estrus as compared to 73 and 72 days for cows which received 75% and 150%. Groups fed 150% of their requirement (groups

III and V) had a higher percentage of cows settled at first service than the 50% or 100% groups (83% and 87% vs 54% and 31%). Cows fed 150% of their requirement had larger follicles and greater ovarian volume ($P<0.01$) during the 5 week period before the onset of estrus. Percentage of cows diagnosed pregnant was 72, 79, 92, 70 and 100 for groups I through V, respectively.

Cantrell (1980) fed 101 fall calving Angus x Hereford cows in moderate body condition to either maintain or lose ten percent of their post-calving body weight by the start of the breeding season. Moderate cows maintained their body weight and condition, however, low cows lost only 3.7% of their post-calving weight and lost 0.8 units of body condition (scale: 1=very thin 9=very fat). Average postpartum interval was 21.7 days shorter for moderate cows. Low level cows had conception rates 11.7% lower than moderate cows.

Echternkamp (1982) fed 36 Hereford heifers to gain approximately 2.6 lb./day pre-calving and 1.6 lb./day post-calving (high), or a maintenance ration (low). One hundred percent of the heifers fed the high energy diet ovulated by 46 days post-calving, where as, heifers fed maintenance diets failed to ovulate by this time. Also, plasma LH concentrations were higher for well fed heifers (3.3 vs 2.4 ng/ml).

Body Condition and Weight Change

Body condition is a subjective concept intended to summarize the degree of fat cover of an animal in relation to size. Body condition of cows is influenced by previous nutritional regime, age of cow and the weaning age of her previous calf. Body condition is generally directly linked to the nutritional status of a cow over a given period of time. Using postpartum beef cows, Dunn et al. (1983) reported that body condition score of the live animal (scoring system; 1=very thin, 9=very fat) was closely related to carcass energy content and to carcass fatness (r=.77 to .86). Most studies measuring body condition have suggested that if significant body fat stores are lost, body condition will influence reproductive performance.

Schake and Riggs (1973) used Hereford cows averaging 11 years of age to determine how changes in live weight influence body composition. Percent fat, protein and moisture in the empty body and soft tissues were not significantly altered by body weight changes. Trends in body composition suggested a consistent protein content with inverse changes in fat and moisture in the presence of significant empty body weight changes. This report contradicted previous findings using carcasses from young steers. It was suggested that the advanced age of the cows influenced tissue stability.

Wettemann et al. (1982) in an experiment with 35 spring calving Hereford range cows, found that either body weight or body condition change before calving can be used to estimate rebreeding performance. Percent decrease in body weight from November until calving was correlated with days to first estrus ($r=.58$; $P<0.01$) and days to conception ($r=.60$; $P<0.001$). Correlations of similar magnitude were found for change in body condition from November to calving. Wettemann et al. (1980) found differences in body condition change reflected differences in live weight change.

In a study with Santa Gertrudis cows and a 60 day breeding season, Wiltbank (1979) reported the pregnancy rate was only 24% for cows scoring 4 at calving compared to 87% for cows scoring a 7 (scale

1=very thin; 9=very fat). Sixty five percent of the cows scoring a 7 were pregnant in the first 20 days of the breeding season.

In another study Wiltbank (1979) reported that cows losing weight after calving had lower conception rates than cows gaining weight. Cows were fed either 8 lb. or 16 lb. TDN/head/day from calving to breeding. After 20 days breeding, conception rates were much lower for cows losing weight (29% vs 57%). By 90 days conception rates were 72% and 82%, respectively. Wiltbank stressed the amount of energy needed varies according to body condition and the stage of reproduction. From 100 to 120 days before calving a thin cow needs 4 lb. of TDN/head/day more than a cow in moderate condition. Thin cows also need about 4-6 lb. of TDN/head/ day more than cows in good condition to provide milk and make a weight gain.

Wiltbank et al. (1964) used 5 postpartum energy levels to determine their effect on postpartum reproduction. All groups, except the group receiving 150% of their TDN requirement, lost weight during the first 28 days postpartum. The loss was most sever in cows receiving 50% of their recommended requirement. Between 28 and 56 days postpartum "50%" cows lost weight, "100%" cows maintained their weight and "150%" cows gained weight. After calving, all groups increased body weight between day 56 and 84. Rate of gain was closely related to the level of TDN fed. Changes in body condition scores generally paralleled the changes in body weight. Body condition decreased from 6.8 at 140 days before calving to 3.7 after calving (scale 1=very thin; 9=very fat). All groups increased their body condition throughout the postpartum period. Body condition scores at day 84 post-calving were 4.4, 5.0, 7.3, 4.5 and 5.8 for groups 1 through 5, respectively.

Ninety days post-calving the percentage of cows showing estrus was 64, 93, 77, 62 and 73 of treatments 1 through 5, respectively.

Lowman (1979) measured cow performance in a fall calving herd with 3 different levels of nutrition during the first 150 days postpartum. Condition score changes were similar to those for live weight change in all 3 treatments. Nutritional level had a significant effect on both condition score change ($P<0.001$) and live weight change ($P<0.001$). There was a significant ($P<0.05$) linear trend for milk production to decline as energy intake declined. There was no difference between groups in the gross energy of milk produced.

Donaldson et al. (1967) studied reproductive efficiency in six herds of beef cattle in North Queensland. Pregnancy rates were greater for cows in good body condition than for thin cows (79.8% vs 39.9%). Forero et al. (1980) reported condition scores changes followed observed live weight changes. Conception rates were 94, 50, 76, 53 and 44 percent for cows that lost 7, 16, 17, 18 and 21 percent, respectively, of their November weight by early February.

Furr (1959) conducted studies with 68 fall calving Hereford cows. Over a four year period, weight losses ranged from 25 to 30 percent each year. Cows were wintered on native range and were fed 1.5 lb. cottonseed meal, or 2.5 lb. cottonseed meal and 3 lb. grain/head/ day. Average 4 year weight losses were 36 pounds greater for low level cows. Performance of mature cows was not affected by this weight loss, however, performance of first calf heifers tended to be depressed.

Using data collected on 686 Angus and Hereford cows, Whitman et al. (1975) reported that for each 10 day interval during 60 to 90 days postpartum, the likelihood of estrus increased (P< 0.05) as body condition at calving improved from thin to moderate to good. However, body condition at first breeding did not effect conception at first breeding. Weight change pre- and post-calving had a significant influence on the likelihood of estrus 40 to 50 days postpartum (P< 0.01).

Milk Production and Calf Performance

Fall born calves in Oklahoma cannot efficiently utilize dormant forage, so milk production of the dam is critical in determining calf weight gains during the winter. Milk production in beef cows is influenced by breed, nutritional status, number of calves nursing and the cow's genetic potential. Most studies have correlated milk production to calf weight gains, particularly in early lactation. In fall calving herds, forage quality generally decreases as lactation progresses, while the reverse is usually true in spring calving herds. Calves from cows on low energy levels before calving tend to have lighter birth weights, reduced survival rates and reduced weaning weights (Corah, 1975).

Neville (1962) used three years data from 135 non-creep-fed Hereford calves to investigate the influence of milk production and other factors on 120 and 240 day weights. Cows were placed on 1 of 3 energy intakes. It was noted that as cow nutrition improved milk production increased, and with this increase, there was a lower correlation between milk production and 240 day weight. The within-year correlations between milk production and calf 240 day weight were .90, .83 and .69 for the low, moderate and high energy levels, respectively. The relationship of milk production to calf weight gain was greatest during the first 60 days of the calf's life and declined slightly by weaning.

Furr and Nelson (1964) conducted 3 studies using 4, 3 and 2 year old (for trail 1, 2 and 3 respectively) fall calving Hereford cows to determine the effects of different levels of supplement on cow and calf performance. Low level intake was 2.5, 2.5 and 2.8 lb. of cottonseed meal/head/day, and high was 6.6, 6.25 and 7.35 lb. of 40% cottonseed meal and 60% ground milo mix/head/day for trail 1, 2 and 3, respectively. In all trails cows fed the low level of supplement lost the most weight, however, this difference was not significant. Milk production increased with the availability of spring grass, with the greatest increase in cows wintered on the low level of supplement. Milk yields generally increased with the higher level of supplementation although the difference was significant in only one trail. Correlations between milk production and average daily gain of calves were .75 and .91, and significant in six of nine groups.

Melton et al. (1967) used 15 Angus, 15 Charolais and 15 Hereford cows to measure milk yield and composition, and calf gains. Calf ADG and cow milk production were significantly correlated when calves were 60 to 90 days of age (r=.58). In agreement with previous research, as lactation progressed this relationship tended to decline. Reynolds (1978) used ten spring calving breed groups to compare milk yields and calf growth rate. Dams were maintained on similar levels of nutrition. Milk yields were significantly correlated to calf growth rate from birth to weaning, with the highest correlations in early lactation.

Bond and Wiltbank (1970) fed 44 grade Angus heifers different levels of protein and energy. Calves from low protein or energy cows converted milk to gain more efficiently than calves from cows fed medium or high protein or energy rations. However, calves from cows fed medium or high protein or energy gained faster.

Velasco (1962) fed spring calving Hereford cow either a low, medium or high level of winter supplement. Milk production was an average of 2 pounds per day less for low cows as compared to high cows. Also, low cows weaned calves that were an average of 56 pounds lighter than those from cows on the high treatment. The correlation between average daily gain and milk production was almost always significant during the first 3 to 4 months of lactation with smaller correlations in later months.

Suckling, Dystocia, Age of Cow, Date of Calving, and Uterine Involution

Suckling increases the postpartum anestrus interval (Saiduddin, 1967; La Voie, 1981; Oxenreider, 1968; Graves, 1968; Bellows, 1974). Suckling will delay postpartum estrus activity independent of nutrient intake (Short, 1972). Removing calves at birth reduced the number of days to first estrus (65 vs 25), however, days from calving to conception were not significantly different (61 vs 50). Wettemann et al. (1978) found that cows suckling 2 calves had significantly longer postpartum intervals than cows suckling only one calf.

Laster (1973) showed that dystocia, or calving difficulty, affected rebreeding performance in beef cows by reducing the percentage of cows detected in estrus and reducing the conception rate. Age of dam, sex of calf, sire breed and dam breed significantly influenced calving difficulty when birth weight was not included in the model ($P<0.05$).

Older cows have shorter postpartum anestrus intervals than younger cows (Wiltbank, 1970). Cows 5 years and older came into estrus sooner than 3 and 2 year olds (53.4 days vs 66.8 and 91.6 days). The cause of the age affect was not known. Donaldson et al. (1967) reported that younger lactating cows had lower pregnancy rates than older cows. Thus, younger lactating cows need more attention than older cows.

Bellows and Short (1978) indicated that date of calving affected the postpartum interval in spring calving heifers. The later in the year that calving occurred, the shorter the postpartum interval. Warnick (1955) found that spring calving Angus and Hereford cows which calved early in the season had longer postpartum intervals than cows which calved late in the season. Covariance analysis demonstrated a significant negative relationship between date of calving and the length of the postpartum anestrus period.

Uterine involution, as detected by rectal palpation, can vary from 27-56 days (Kiracofe, 1980; Oxenreider, 1968). Rectal palpation evaluates the size, tone and position of the uterus, however, this gives no estimate of the amount of epithelial regrowth which has occurred. Geir and Marion (1981) considered involution to be completed by 40-60 days post-calving, when caruncles had regressed to a smooth, oblong, epithelial covered, avascular knobs. For involution to be completed they reasoned that a variety of histological and physical overlapping processes must take place: (1) reduction in size (2) loss of tissue and (3) repair. The time it takes caruncular tissue to be sloughed and expelled varies from 8-15 days. Also, regeneration of uterine epithelum tissue begins very early and lasts from 25-30 days postpartum (Wagner and Hansel, 1969; Geir and Marion, 1968).

Suckling, ovariectomy or removal of the corpus luteum appeared not to influence uterine involution (Wagner and Hansel, 1969; Oxenseider, 1968). Kiracofe (1980) stated that the net effect of nutrition on uterine involution appeared to be minimal in the absence of specific deficiencies. Reports on the influence of uterine involution on the postpartum interval and conception appears to be confounding. Kiracofe (1980) listed several reports in which researchers found little or no relationship between uterine involution and the postpartum interval or conception rates in clinically normal cows approximately 40 days postpartum.

Progesterone

The major source of progesterone during late pregnancy is the ovary. However, it has been suggested that the adrenal gland may be involved in the maintenance of pregnancy during late gestation (Wendorf and First, 1977). During late pregnancy, plasma progesterone concentrations are similar to those during the luteal phase of the estrus cycle. About 1 day before parturition, progesterone levels decrease rapidly to less than 1 ng/ml (Wettemann, 1980). Edgeston and Hafs (1973) reported that progesterone decreased from 8.0 ng/ml 1 to 2 weeks prepartum to 0.9ng/ml at parturition. Reductions in plasma progesterone are due to reduced luteal activity. The corpus luteum of pregnancy is regressing between 2-4 days postpartum (Oxenreider, 1968), and is non functional by day 7 after calving (Wagner and

Hansel, 1969).

Progesterone concentrations remain low (<1 ng/ml) until the onset of ovarian activity during the postpartum period (Smith et al., 1973; Arije et al., 1974; Rawlings et al., 1980; Edgeston and Hafs, 1973; Corah et al., 1974). Humphrey et al. (1983) reported that serum progesterone from parturition until an average of 4.6 days before first estrus fluctuated between undetectable levels and 0.5 ng/ml. Other studies have also shown that progesterone concentrations increase about 4 days preceding the first postpartum estrus (Arije et al., 1974; Rawlings et al., 1980; Castenson et al. 1976; Donaldson et al., 1970).

It has been suggested these progesterone increases are associated with follicular development and luteinization of follicles (Donaldson et al., 1970; Corah et al., 1974; Castenson et al., 1976). Castenson et al. (1976) reported that these increases are sometimes due to ovulation without estrus and subsequent formation of a corpus luteum. Short estrus cycles (6-8 days) were noted after first estrus in heifers which failed to exceed progesterone levels of 0.6 ng/ml (Corah et al., 1974).

Progesterone concentrations following estrus have been reported to be higher for pregnant cows than non-pregnant cows at 15-18 days post-estrus (Arije et al., 1974; Wettemann and Hafs, 1973). Edgeston and Hafs (1973) found progesterone concentrations were very similar in both fertile and infertile Holstein cows from estrus to 11 days post-estrus. By day 20 post-estrus progesterone concentrations in pregnant cows reached 12.2 ng/ml, however in non-pregnant cows the maximum concentration was 7.8 ng/ml on day 15 and declined until the next estrus.

Cold Stress and Animal Performance

Increased heat production during cold stress requires an immediate utilization of energy substrates from either the diet or from tissue reserves. However, present NRC requirements have been established in animals under no thermal stress (NRC pub., 1981). For this reason, the effect of cold stress on animal performance is of great concern, particularly in fall calving herds. Lower critical temperature is determined by environmental temperature, wind chill, moisture, and the amount of insulation provided by fat, hide, wool or hair (Ames, 1978; Ames et al. 1975). Increased maintenance requirements for livestock exposed to effective temperatures below the thermoneutral zone (TNZ) have been reported by several researchers (Blaxter and Warnman, 1964; Hidiroglou and Lessard, 1971; Webster et al., 1971).

Webster et al. (1970) found that cold exposed beef cattle increased hay consumption 21-26 percent. Significant increases in resting metabolic rate (RMR) with increasing severity of cold was also reported. Although it could not be confirmed, authors speculated the increased RMR could be due to increased thyroid activity.

Young (1975) used housed and non-housed pregnant heifers, fed the same amount of ration, during a Canadian winter to study effects of winter acclimatization on resting metabolism of beef cattle. Resting metabolic rates (RMR) and the temperature of its occurrence were estimated by regression analysis to be 3.13 Kcal/h./kg$^{3/4}$ at 30 C for housed heifers. RMR's for heifers kept outside were 3.71 and 4.29 Kcal/h./kg$^{3/4}$ at 17.4 and 12.7 C during early and late winter, respectively. This study demonstrated that increases in metabolism were independent of differences in food intake. Cold adapted animals appeared to have a greater capacity to produce heat during periods of severe cold stress. During severe cold stress, unacclimatized heifers could not produce enough heat to maintain body temperature.

Using 7 years of data on 1,970 steers, Milligan et al. (1974) reported that average daily gains were reduced by 70% during winter months (Dec., Jan. and Feb.) as compared to the mean of all other months in Canada. Feed per unit of gain was increased 49% over that for summer months. ADG and F/G were significantly correlated with mean ambient temperature. Hidiroglou and Lessard (1971) found that steers wintered outside in Canada required 16% more TDN for maintenance than steers wintered inside. This was 42% greater than proposed NRC requirements.

CHAPTER III

MATERIALS AND METHODS

Studies were conducted during the fall and winter of 1980-81, 1981-82, and 1982-83 to determine the effect of different levels of postpartum nutrition on the reproductive performance of fall calving Hereford cows and their related calf performance. Studies were conducted at the Lake Carl Blackwell Range Cow Research Center in North Central Oklahoma. Fifty four, 54 and 58 mature Hereford cows, ranging in age from 3 to 12 years, were used in years 1, 2 and 3, respectively. Cows grazed Bermuda (Cynodon dactylon) pastures until calving, and calved in good condition each year. After calving cows were moved to native pasture, predominantly little bluestem (Andropogon scoparius), big bluestem (Andropogon gerardi), yellow indiangrass (Sorghastrum nutans) and switchgrass (Panicum virgatum), with a carrying capacity of approximately 12 acres per cow-calf unit. Native forage in North central Oklahoma is generally dormant from mid-October to early May.

One day each week, cows with calves at least 2 days old were weighed (first postpartum weight), scored for body condition (1=very thin, 9=very fat) and allotted to one of three treatments based on date of calving. Treatments were: (1) maintain weight from calving through breeding, (2) lose 10 percent of their postpartum body weight from calving to the beginning of breeding and maintain their weight during breeding and (3) maintain weight from calving to breeding followed by a loss of 10 to 15 percent of their postpartum body weight during the breeding season.

To achieve the moderate level of nutrition control cows (group 1) and group 3 were maintained on abundant forage and fed 2 to 3 lb./head/day of cottonseed cake (41% crude protein) from calving until breeding (Oct. 1 - Dec. 1). To achieve the desired weight loss in group 2, cows grazed native pasture, in which there was limited forage, and were fed no supplement. During breeding, cows in groups 1 and 2 grazed dormant native forage and were fed 4 lb. of cottonseed cake (41% crude protein) per head per day. Cows in group 3 grazed abundant native pasture and was fed no supplement during the breeding season (Dec. 1 to Feb. 1). After breeding all cows were fed 3 to 4 lb. of supplement/head/day until mid-April. Supplement amounts were prorated for feeding on Mon. Wed. and Fri. of each week. Hay was fed during extreme cold temperatures or when snow and ice covered the dormant forage. Group 2 cows were never fed hay from calving to breeding. Years 1 and 3 were very mild but year 2 was cold with extended periods of rain and ice. Calcium, phosphorus and salt (60%-40%) mineral mix was fed free choice during each experimental period.

Cows were weighed, after a 24 hour shrink, and scored for body condition at 2 week intervals from calving to the end of breeding and at 28 day intervals to weaning. Exception to this procedure was in year 1 when cows were scored for body condition at 28 day intervals from calving to weaning. Estrus was detected by sterile bulls with chin-ball markers before breeding and by marker-equipped fertile bulls, which were rotated weekly among pastures during the breeding season. Hereford and Angus bulls were used in year one, while in years 2 and 3 only Hereford bulls were used to breed cows. Pregnancy status was determined by rectal palpation in mid-April each year. Days to first estrus (postpartum anestrus interval) was defined as the number of days from calving until the first standing heat. Days to conception was calculated, on available cows, by subtracting 283 days from the subsequent calving date.

All calves were weighed and identified by ear tag and tattoo and males were castrated by banding within 24 hours after birth. All calves remained with their dams on pasture without creep feed. Calves were weighed at the beginning and end of the breeding season and at weaning. At the end of the breeding season, calves were vaccinated for blackleg and malignant edema. In addition, female calves were vaccinated for brucellosis. Weaning weights were adjusted to 205 day equivalents using age of dam adjustments suggested by Beef Improvement Federation guidelines (Hubberd, 1981). Birth weights for heifer calves were corrected to a steer equivalent by multiplying by 1.07.

Progesterone Analysis

Blood was obtained via tail vein at weekly intervals during the eight week breeding seasons. Oxalic acid was added to each blood sample at the time of collection to prevent coagulation. Each sample was cooled and centrifuged within 2 hours to remove cells. Plasma was decanted and stored at -15 C until progesterone was quantified. Plasma progesterone concentrations were determined by radioimmunoassay procedures as described by Lusby et al. (1981). Ovarian activity was indicated by plasma progesterone concentrations greater than 1 ng/ml for 2 consecutive weeks. Wettemann et al. (1972) reported that the presence of a functional corpus luteum will cause plasma progesterone to increase greater than 1 ng/ml for at least 15 days during the normal estrus cycle. Evaluation of blood samples taken at weekly intervals for progesterone concentrations should have been adequate to detect the presence of normal estrus cycles or pregnancy.

Statistical Analysis

Data were analyzed by general least squares linear models procedures. Protected least significant difference procedures were used to determine differences between treatment means. For the dependent variables, initial weight, initial condition score, weight changes, condition score changes and percent cows pregnant, the main effects treatment, age of cow, calving month and all two-way interactions were included in the model. The model for days from calving to first estrus, days from calving to conception included treatment, age of cow, calving month, year and all two-way interactions. For the dependent variables, ovarian activity at the end of breeding and luteal activity post-estrus, the main effect was treatment. The model for ovarian activity at the beginning of breeding included the main effects treatment, year and treatment x year. Regression coefficients of body weight and condition change for percent cows pregnant, and ovarian activity at the end of breeding were obtained by partial linear regression analysis.

For the dependent variables, 205 day weight and 205 average daily gain, main effects treatment, sire breed, birth month, year and all possible two-way interactions were included in the model. The model for calf weight at the beginning of breeding and calf weight at the end of breeding included treatment, sire breed, birth month, sex of calf, age of dam, year and all two-way interactions.

CHAPTER IV

RESULTS AND DISCUSSION

Weight and Condition Changes

Weight and body condition changes are in Table I and in Figures I, II and III. Due to significant treatment x year interactions, weight and condition changes are presented by year.

Exact weight changes described in the materials and methods were not obtained because energy intake was not rigorously controlled. Forage and supplement conditions were designed to simulate actual ranch conditions. Thus as in actual ranch practice, weather and forage conditions had a major impact on weight changes. One to four pounds of supplement was fed per head per day, depending upon estimated forage quality and availability. Although higher levels of supplement would have increased total energy intake, these levels are not a practical alternative for the Oklahoma rancher and therefore were not fed.

Year 1

Because of an abnormally mild winter and abundant forage in year 1, cows on treatment 2 lost only 3.1 percent of their body weight before the breeding season. Weight and condition changes were very similar for cows in groups 1 and 3 (-6 vs -9 lb.; -.27 vs -.38 units, respectively), which were treated alike before the breeding season. During the breeding season, cows in group 3 lost 149 lb. of body weight and .93 units of body condition. Cows in groups 1 and 2 lost 51 and 67 lb. of body weight and .36 and .20 units of body condition, respectively, during breeding.

Weight losses following the breeding season were the inverse of weight losses from calving to the end of breeding. During this time all groups were pastured together and fed the same amount of supplement. Group 1 cows were the heaviest at the end of breeding, and lost the most weight from February to April. However, cows in group 1 were still the heaviest in April. Group 3 cows were the thinnest at the end of breeding, but lost the least during this time period. Group 2 cows were intermediate.

Year 2

Cows calved in a slightly lower body condition during year 2 as compared to cows in year 1. Forage conditions were poorer and the weather was much more severe during the second year. Therefore, cows in year 2 experienced greater weight losses both before and during the breeding season. Before breeding, cows in group 2 lost more weight and body condition (17% and 1.4 units; $P<0.01$) than cows on treatments 1 or 3. Cows in group 1 lost slightly less weight than cows in group 3 (4% vs 7%) even though both groups were pastured together until breeding, but lost similar amounts of body condition (.4 vs .3 units, respectively).

During the breeding season, cows on treatment 1 lost more weight and body condition than cows on treatment 2 (86 vs 4 lb.; -.37 vs +.05 units; $P<0.01$). Cows on treatment 1 lost less weight and body condition than cows on treatment 3 (86 vs 106 lb.; .37 vs 1.37 units;

P<0.01). With the forage and weather conditions experienced in the second year, protein supplement and standing forage were inadequate to maintain weight in these lactating cows. Post-breeding weight and body condition change trends in year 2 were in agreement with changes in year 1.

Year 3

In year 3, cows calved at approximately .5 to 1.0 units of body condition lower than in years 1 and 2 (refer to Table I). More supplemental hay was made available in year 3 so that weight changes could be controlled more closely. However, standing forage was adequate and the winter was quite mild both before and during the breeding season in year 3.

Prior to breeding, cows in group 2 lost an average of 6% of their post-calving body weight and .68 (5.2 at calving) units of body condition. Cows in groups 1 and 3 lost only 1 to 2 percent of their body weight and .26 and .30 units of body condition, respectively. During the breeding season, cows on treatment 3 lost significantly more body weight and condition as compared to cows on treatments 1 and 2 (91 lb. vs 30 and 15 lb., respectively; P<0.01). Due to forage and weather conditions, group 2 cows lost only 15 lb. and regained .38 units of body condition. One third of a unit of body condition is well within the judgement error of this subjective measure. As in years 1 and 2, cows which were the heaviest at the end of breeding lost the most weight from breeding to weaning.

Body condition losses generally followed body weight losses each year. In all three years, post-breeding weight and condition changes tended to follow the same patterns. This could be due to decreased milk production, more efficient digestion, increased metabolic efficiency or a combination of these factors. Perhaps nutritionally stressed cows can more readily mobilize energy stores, to a point, and thus maintain weight more efficiently. Increased efficiency of metabolism would result in a lowering of the total maintenance energy requirement. Wagner et al. (1984) has demonstrated that non-pregnant, non-lactating Hereford cows in thin body condition (2 to 4.5) have lower maintenance energy requirements than cows in moderate body condition (4.5 to 5.5).

During periods of severe cold (refer to year 2) marked changes in weight loss patterns can be noted. In order for cows to maintain body temperature during these periods, the animals must generate added body heat, thus maintenance requirements for energy must also increase. Several researchers have reported increased maintenance energy requirements for livestock exposed to temperatures below the thermoneutral zone (Blaxter and Wainman, 1964; Webster et al., 1971). Hidiroglou and Lessard (1971) found that steers winter outside in Canada needed 16% more TDN for maintenance than steers wintered inside. Weight loss patterns in this study indicate that standing dormant forage alone could not meet this added requirement. Even with supplemental hay, body weight could not be maintained when these lactating cows were exposed to rain, snow and severe cold for extended periods of time. The most nutritionally critical time in a mature cow's life is during lactation. The maintenance energy requirement of the lactating cow is about 30% to 40% greater than for a dry cow, and total protein requirement is essentially doubled. With this in mind, one can easily understand why the impact of cold stress can be so detrimental to the lactating cow.

Calf Performance

Calf weights and 205 average daily gains are reported in Table IV. Because there were no significant treatment x year interactions, calf weights were averaged for all 3 years. The 205 day weights were adjusted for sex of calf, age of dam (by factors suggested by Hubbard, 1981), sire breed and calving month.

Although there were no significant differences, calves from cows on treatment 2 tended to be lighter at the beginning of the breeding season than calves from cows on treatments 1 and 3 (136 lb. vs 148 and 153 lb., respectively). Milk production was apparently reduced in the nutritionally stressed cows (group 2). Although milk production was not measured in this study, other studies have shown decreased milk production and lighter calf weights from cows on low planes of nutrition (Furr and Nelson, 1964; Velasco, 1962). Neville (1962) demonstrated the relationship of milk production to calf weight gain was greatest during the first 60 days of the calf's life. Bond and Wiltbank (1970) demonstrated that calves from low energy intake cows converted milk to gain more efficiently than calves from well fed cows, but the latter gained faster. If cows from higher milk producing breeds were used in this study perhaps the influence of treatment on calf weights would have been more dramatic.

Calf weights at the end of the breeding season were not significantly different for treatments 1, 2 and 3 (204, 193 and 188 lb., respectively). Calf weaning weights were low, reflecting the fact that 205 day adjusted weights were computed based on April weights and calves were not creep fed. Under conditions of this study, calves had to rely primarily on milk for their total nutrient supply. Spring forage was only available for 2 to 3 weeks before weaning and dormant, winter forage would have been of little value to these calves. Weaning weights from calves in groups 1 and 2 were similar (310 and 313 lb., respectively), with group 3 calves tending to weigh somewhat less (297 lb.).

Reproductive Performance

Cow reproductive performance is reported in Tables II and III. Due to significant year x treatment interactions, percent cows pregnant, percent ovarian activity at the end of the breeding season and percent luteal activity post-estrus are presented and discussed by year. Other reproductive traits were averaged for all three years.

Weight and body condition loss prior to breeding (Table I) tended to increase the number of days from calving to first estrus (group 2) ($P<0.07$). Cows in groups 1 and 3 averaged 58 days from parturition to first estrus, while the average for group 2 was 69 days. This effect was evident each year. These data show that body weight and condition loss prior to the breeding season can lengthen the postpartum anestrus interval in cows which calve in good body condition. The sensitivity of cow reproduction to weight and condition loss during this time appears to be fairly high. Cows which were forced to lose weight prior to the breeding season (group 2) had longer postpartum anestrus intervals when body loss was 3, 17 and 6 percent of their first post calving weight (years 1, 2 and 3, respectively). Cantrell (1980) reported that a weight loss of 3.7% from calving to the beginning of breeding increased the postpartum anestrus interval by 22 days in fall calving Angus x Hereford cows. These conclusions do not agree with data presented by Holness and Hopley (1978). These researchers reported that lowering nutrient intake from day 25 to day 50 postpartum did not change live weight or lengthen the postpartum interval to estrus. However, spring calving cows used in their study were in excellent body condition at this time, and precalving nutritional regimes were high in energy. Wiltbank (1962) reported that cows which calve in good condition, but lost weight after calving, had shorter postpartum anestrus intervals than cows which maintained weight prior to, and after calving. However, he also used spring calving cows in this study.

The number of cows with ovarian activity at the start of the breeding season was determined by presence of plasma progesterone greater than 1 ng/ml for two weeks in succession (Table II). Ovarian activity at the beginning of breeding was reduced in cows on treatment 2, as compared to cows on treatment 1 (37% vs 64%; $P<0.01$). This can be related to the lengthening of the postpartum anestrus interval and reduced number of cows cycling in group 2. The number of cows detected in estrus by marker equipped bulls from calving to the end of breeding tended to be reduced by decreased levels of nutrition both before and during the breeding season (Table II).

When averaged across years, cows in group 3 had reduced ovarian activity at the beginning of the breeding season, as compared to control cows (group 1) (42% vs 64%, respectively; $P<0.01$). This reduced cyclic activity during the beginning of breeding was also noted by observers during data collection. Cows in groups 1 and 3 were fed the same prior to breeding. At day 1 of the breeding season, group 3 cows were placed on dormant standing forage and fed no supplement. This suggest that the cow is much more sensitive to rapid changes in nutrition status than previously thought.

The sensitivity of ovarian activity to short term nutritional stress was one of the most interesting and significant findings of this study. Design of this experiment limited investigation into the mechanisms of action behind this phenomenon. Results from this study warrant future investigation into this area. Perhaps blood volatile fatty acids, glucose, amino acids or a variety of other nutritionally oriented parameters are monitored by the hypothalamic - pituitary - ovarian axis. If this is the case, and these parameters can be isolated, specific feeding and management practices could be designed to promote more efficient and effective rebreeding performance. Also of interest would be the interactions between these nutritional factors and body condition of the cow (i.e. condition score 7 vs 5 vs 3).

Days from calving to conception were calculated, on available cows, by subtracting 283 days from the subsequent calving date. Mean days from calving to conception were 81, 82 and 86 days for cows on treatments 1, 2 and 3, respectively. This slight difference could be explained by the fact that a large percentage of the cows that did conceive were bred early in the breeding season. However, it should be noted that fewer cows in groups 2 and 3 were cycling and actually became pregnant (Table II; Table III).

In year 1, mean pregnancy rate was significantly lower for cows on treatment 3, than for cows in groups 1 and 2 (50% vs 79% and 88%, respectively). Ovarian activity during the last 2 weeks of the breeding season was reduced ($P<0.01$) for cows on treatment 3 (35% vs 95% and 94%). There was also a significant reduction in the percentage of cows in group 3 that maintained luteal activity after exhibiting estrus (41% vs 93% and 79%).

In the first year, the 3% weight loss for cows in group 2 did not appear to influence reproductive performance, other than lengthen the postpartum anestrus interval. Cows on treatment 3 maintained their weight before breeding, but lost 14% of their post-calving weight and 1 unit of body condition during the breeding season. It appears that body weight and condition losses of this magnitude can reduce the number of cows cycling during the breeding season, reduce the conception rate of those that do cycle and thus, reduce the number of cows pregnant. These data indicate that reproductive performance of cows in good body condition at the beginning of the breeding season can be suppressed dramatically if significant weight losses are allowed during the breeding season.

The winter of year 2 was harsh, with only a moderate amount of forage available. As previously stated, cows in group 2 lost 17% ($P<0.01$) of their post-calving weight prior to breeding, but an average of only 4 pounds during breeding. Cows in group 3 lost 6% of their body weight before breeding and 11% of their post-calving weight during breeding.

Percent cows pregnant was reduced for treatments 2 and 3, as compared to group 1 (53% and 67% vs 87%, respectively). However, this difference was not significant (Table III). The percentage of cows with normal ovarian activity at the end of breeding was reduced accordingly (93, 47 and 70% for groups 1, 2 and 3, respectively).

The percentage of cows in group 2 which had luteal activity after standing heat was 71%, compared to 100% in group 1. One hundred percent of the cows in group 3 had luteal activity following estrus. Although 100% appears high, one must remember that only 70% of the cows on this treatment had luteal activity at the end of the breeding season. These data suggest that a severe weight loss (group 2 = 17%) prior to breeding can suppress normal luteal function during the breeding season and reduce the number of cows pregnant at the end of the breeding season (87% vs 53% for groups 1 and 2, respectively).

Weight losses of the magnitude experienced by cows in group 3 can also reduce ovarian activity and pregnancy rates. Total weight and body condition loss from calving to the end of breeding was about the same in years 1 and 2 for cows in groups 3 (Table I). Although the reproductive performance of group 3 cows was impaired in both years 1 and 2, performance in year 1 was the most depressed. This would indicate that the rate at which body weight and condition are lost can greatly influence the depression of ovarian function. Perhaps during periods of gradual weight loss cows can adjust metabolic function more readily. This would be very dependant upon the amount of body energy the cow has. Somerville et al. (1979) reported the rate of live weight loss experienced by a cow up to breeding has more effect on fertility than absolute live weight at breeding.

In year 3, cows in group 2 lost 6% of their post-calving weight and .68 units of body condition before calving, but only 15 lb. during breeding. Cows in group 3 lost only 21 lb. before breeding and 9% of their post-calving body weight and .69 units of body condition during breeding. Pregnancy rates were similar for all treatments (Table III). There were fewer cows with ovarian activity at the end of breeding in group 2 (64%), than cows in groups 1 and 3 (89% and 83%, respectively). The number of cows which maintained luteal function following estrus was greater for treatment 1 (94%), than treatments 2 and 3 (64% and 67%, respectively).

Data from year 3 suggest that luteal function can be diminished by weight losses both before and during the breeding season (Table III). The loss of 6% of body weight prior to breeding (group 2) was apparently sufficient to reduce the number of cows cycling at the end of the breeding season and to reduce the number of cows which maintained luteal activity after standing heat. As compared to group 1, weight loss during breeding (group 3) did not greatly influence the percent of cows which maintained ovarian activity during the last 2 weeks of the breeding season (89% vs 83%, respectively). However, weight loss during breeding tended to reduce the number of cows which had luteal activity following estrus (94% vs 67% for groups 1 and 3, respectively).

Wiltbank et al. (1962) fed 83 spring calving cows two prepartum energy levels (high and low) and two postpartum energy levels (high and low). Cows which calved in good body condition, but lost weight after calving (high-low), had the shortest postpartum interval to estrus. However, regardless of prepartum energy regime (Wiltbank et al., 1962), more cows fed high energy levels after calving became pregnant (H-H, 95%; H-L, 77%; L-H, 95%; L-L, 20%). Other research has demonstrated the influence of prepartum nutrition on the postpartum anestrus interval and reproduction (Turman et al., 1964; Corah et al., 1975; Bellows and Short, 1978; Wettemann et al., 1980). Dunn et al. (1969) showed that pre-calving energy level exerted a strong influence on the early postpartum anestrus period, however by 80 days after calving the prepartum energy level was not an important variable. Pregnancy rates at 120 days post-calving were directly related to post-calving energy levels (Dunn et al., 1969). Hight (1968) reported that a low plane of nutrition in late pregnancy did not affect pregnancy rates if cows were well fed after calving. Although prepartum nutrition can mediate, to some extent, early post-calving ovarian function, data from this study, Wiltbank et al. (1962) and Dunn et al. (1969) indicate that good body condition at calving will not guarantee maximum rebreeding.

Partial regression coefficients of body weight and condition loss for percent cows pregnant are presented in Table V. Condition score at calving, condition change to the beginning of breeding and condition change to the end of the breeding season accounted for only a small percentage of the variation for percent cows pregnant (R^2= .043). The R^2 value for weight and weight change during the aforementioned times was also very low (R^2= .071). When the same models were used for ovarian activity at the end of breeding (Table VI), R^2 values were only slightly greater that those for percent cows pregnant (R^2= range .124 - .145).

These data suggest that absolute differences between initial body weight and/or condition at calving, beginning of breeding and end of breeding are inadequate to predict pregnancy status or ovarian activity of the cow herd. Perhaps some intermediate weight change patterns between these point in time are the most valuable predictors. This would be very beneficial during experiments designed to simulate ranch condition where actual energy intake cannot be directly controlled. In future studies, evaluation of the relationship between total weight loss patterns and ovarian function during these critical periods could prove enlightening.

CHAPTER V

SUMMARY AND CONCLUSIONS

The objective of this research was to determine the effect of body weight and condition loss before and during the breeding season on the reproductive performance of fall calving cows and, the pre-weaning performance of their calves. At calving (Sept. - Oct.), Hereford cows were allotted to 1 of 3 treatments, placed on native range and supplemented with 40% protein cubes to: (1) maintain post-calving weight from calving through breeding, (2) lose weight from calving to the beginning of breeding, and be fed similar to group 1 during breeding or (3) maintain weight before breeding and lose weight during breeding. Cows were weighed and scored for body condition at 2 week intervals from calving to breeding. Heat dates were recorded using marker equipped non-fertile and fertile bulls before and during breeding, respectively. Blood was taken via tail vein at weekly bleedings during the breeding season. These samples were analyzed for plasma progesterone to determine luteal activity. Calves were weighed at the start and end of the breeding season, and again at weaning.

Body condition changes generally followed body weight changes. The degree of body weight change was very dependent upon the quality and quantity of forage available, the amount of supplemental protein provided and the severity of cold during the winter. During extended periods of ice, snow and cold, supplemental hay was not adequate to fully maintain body weight in these lactating cows. Weight changes after the breeding season indicate that cows in thin body condition can more readily maintain weight than cows in moderate body condition. This could be due to decreased milk production, increased metabolic efficiency, body composition or a variety of factors.

Weight loss prior to breeding (group 2) tended to reduce calf weights at the beginning of breeding. However, calves from group 2 had compensated for their reduced weight by weaning (Table IV). The 205 day weights for all calves were low, reflecting the fact that calves were weaned in April and received no creep feed. Weight loss of cows during breeding (group 3) tended to reduce the average weaning weight of their calves.

Cows on treatment 3 appeared to be very sensitivity to rapid nutritional changes during the first 2 weeks of the breeding season (ovarian activity; Table II). Investigation into the impact of rapid, short term, nutritional changes on ovarian function warrants future study. Perhaps cows in moderate to fat body condition react differently than thin cow to rapid nutritional changes. An understanding of the relationship between blood parameters and ovarian function within cows of differing body energy could greatly add to our understanding of postpartum reproductive performance.

Weight and body condition loss during breeding can suppress ovarian activity and the number of cows pregnant (Table III). This tends to be mediated by weight change before breeding (year 2 vs year 3; Table III). The rate at which body weight and condition are lost can impact reproductive performance. Rapid weight loss seems to diminish ovarian activity greater than slow rates of weight loss. This can be seen by examining the difference between cow group 3 in years 1 and 2 (Tables I and III).

Weight loss prior to breeding (group 2) can lengthen the postpartum anestrus interval ($P<0.07$). Depending upon severity, pre-breeding weight loss can also reduce ovarian activity during breeding and the number of cows pregnant (group 2; Tables II and III). These data indicate that good body condition at calving will not insure adequate rebreeding, and that reproductive function is sensitive to weight and body condition changes before and during the breeding season.

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APPENDIX

TABLE I

MEAN COW WEIGHT AND CONDITION CHANGES

	Treatment			
	1	2	3	MSE
Year 1				
Number of cows	19	17	18	
Cow wt., lb.				
After calving	1041	1021	1027	7220.8
Change to breeding	-6	-32	-9	1605.0
Change during breeding	-51[a]	-67[a]	-149[b]	1765.2
Change from breeding to weaning	-118[a]	-85[b]	-54[c]	1362.0
Condition score				
After calving	6.4	6.2	6.4	.2724
Change to breeding	-.27	-.30	-.38	.1408
Change during breeding	-.36[a]	-.20[a]	-.93[b]	.1866
Change from breeding to weaning	-.24	-.25	-.12	.1351
Year 2				
Number of cows	15	19	20	
Cow wt., lb.				
After calving	1015	1020	997	7589.1
Change to breeding	-45[a]	-175[b]	-69[a]	1939.9
Change during breeding	-86[a]	-4[b]	-106[c]	149.1
Change from breeding to weaning	-70	-61	-56	707.1
Condition score				
After calving	6.3	6.3	6.2	.1422
Change to breeding	-.40[a]	-1.4[b]	-.30[a]	.2234
Change during breeding	-.37[a]	+.05[b]	-1.37[c]	.3029
Change from breeding to weaning	-.87	-.55	-.32	.2029
Year 3				
Number of cows	19	19	20	
Cow wt., lb.				
After calving	958	963	960	10425.4
Change to breeding	-12	-58	-21	2167.5
Change during breeding	-30[a]	-15[a]	-91[b]	1178.3
Change from breeding to weaning	-133	-102	-82	1436.1
Condition score				
After calving	5.8	5.2	5.7	.4949
Change to breeding	-.26	-.68	-.30	.1770
Change during breeding	-.28[a]	+.38[b]	-.69[c]	.1442
Change from breeding to weaning	-.56	-.27	-.38	.2007

[a,b,c]Means on the same line with different superscript letter differ ($P<0.05$).

TABLE II

MEAN DAYS FROM CALVING TO FIRST ESTRUS, DAYS FROM CALVING TO CONCEPTION AND OVARIAN ACTIVITY AT THE BEGINNING OF BREEDING SEASON: YEARS 1, 2 AND 3

	Treatment			
	1	2	3	MSE
Number of cows	53	55	58	
Days from calving to first estrus	58	69	58	633.04
Number of cows observed in estrus (percent)	47 (89)	42 (76)	46 (79)	
Days from calving to conception[a]	81	82	86	180.73
Percent ovarian activity at beginning of breeding[b]	64[c]	37[d]	42[d]	.2343

[a]Data generated from 96 total observations.
[b]Plasma progesterone level greater than 1 ng/ml at day 1 and 8 of the breeding season.
[c,d]Means on the same line with different superscript letter differ ($P<0.05$).

TABLE III

MEAN PREGNANCY STATUS, OVARIAN ACTIVITY AT THE END OF BREEDING SEASON AND LUTEAL ACTIVITY POST-ESTRUS

	Treatment			
	1	2	3	MSE
Year 1				
Number of cows	19	17	18	
Cows pregnant (percent)	15 (79)[a]	15 (88)[a]	9 (50)[b]	.1730
Percent ovarian activity[cd]	95[a]	94[a]	35[b]	.1201
Luteal activity post estrus[ef]	93[a]	79[a]	41[b]	.1723
Number in heat	19	17	18	
Year 2				
Number of cows	15	19	20	
Cows pregnant (percent)	13 (87)	10 (53)	13 (65)	.2539
Percent ovarian activity[cd]	93[a]	47[b]	70[ab]	.1935
Luteal activity post estrus[ef]	100[a]	71[b]	100[a]	.0549
Number in heat	15	13	13	
Year 3				
Number of cows	19	19	20	
Cows pregnant (percent)	17 (89)	16 (84)	17 (85)	.1603
Percent ovarian activity[cd]	89	64	83	.1594
Luteal activity post estrus[ef]	94	64	67	.1602
Number in heat	18	15	16	

[a,b] Means on the same line with different superscript letter differ ($P<0.05$).

[c] Plasma progesterone level greater than 1 ng/ml during the last two weeks of breeding season.

[d] Data generated from 155 total observations.

[e] Plasma progesterone level greater the 1 ng/ml following estrus detected by marker equipped bull.

[f] Data generated from 116 total observations.

TABLE IV

MEAN CALF WEIGHTS AND 205 AVERAGE DAILY GAIN: YEAR 1, 2 AND 3

	Treatment			
	1	2	3	MSE
Number of calves	53	55	58	
Calf wt., lb.				
Weight at beginning of breeding	148	136	153	395.77
Weight at end of breeding	204	193	188	700.19
Adj. 205 day weight[ab]	310	313	297	2005.85
Adj. 205 ADG[ab]	1.2	1.2	1.1	.0437

[a]BIF guidelines.
[b]Least squares means.

TABLE V

PARTIAL REGRESSION COEFFICIENT OF BODY WEIGHT AND CONDITION CHANGE FOR PERCENT COWS PREGNANT

Model	Coefficient	SE	R^2	Prob.
First postpartum condition score	.08	.06	.043	<.07
Condition loss to breeding	-.20	.08		
Condition loss during breeding	-.13	.06		
Intercept	.39	.34		
First postpartum weight	.00	.00	.071	<.01
Weight loss to breeding	-.02	.01		
Weight loss during breeding	-.02	.01		
Intercept	.17	.30		
First postpartum condition score	.03	.05	.046	<.01
Weight loss to breeding	-.01	.01		
Weight loss during breeding	-.02	.01		
Intercept	.73	.30		

TABLE VI

PARTIAL REGRESSION COEFFICIENT OF BODY WEIGHT AND CONDITION CHANGE FOR OVARIAN ACTIVITY AT THE END OF BREEDING SEASON

Model	Coefficient	SE	R^2	Prob.
End of breeding				
First postpartum condition score	.24	.06	.145	<.01
Condition loss to breeding	-.40	.07		
Condition loss during breeding	-.24	.06		
Intercept	-.44	.34		
First postpartum weight	.00	.00	.144	<.01
Weight loss to breeding	-.02	.01		
Weight loss during breeding	-.02	.01		
Intercept	-.17	.37		
First postpartum condition score	.14	.05	.124	<.05
Weight loss to breeding	-.02	.01		
Weight loss during breeding	-.03	.01		
Intercept	.21	.31		

TABLE VII

SYSTEM OF BODY CONDITION SCORING
FOR BEEF CATTLE

Score	Description
1	Severely emaciated. All ribs and bone structure easily visible and physically weak.
2	Emaciated, similar to 1 above but not weakened. Little visible muscle tissue.
3	Very thin, no fat on ribs or brisket, and some muscle still visible. Backbone easily visible.
4	Thin, with ribs easily visible but shoulders and hind quarters still showing fair muscling. Backbone visible.
5	Moderate to thin. Last two or three ribs can be seen. Little evidence of fat in brisket, over ribs or around tailhead.
6	Good smooth appearance throughout. Some fat deposition in brisket and over tailhead. Ribs covered and back appears rounded.
7	Very good flesh, brisket full, tailhead shows pockets of fat, and back appears square due to fat. Ribs very smooth.
8	Obese, back very square, brisket distended, heavy fat pockets around tailhead, and cow has square appearance due to excessive fat. Neck thick and short.
9	Rarely seen. Very obese. Description of 8 taken to greater extremes. Heavy deposition of udder fat.

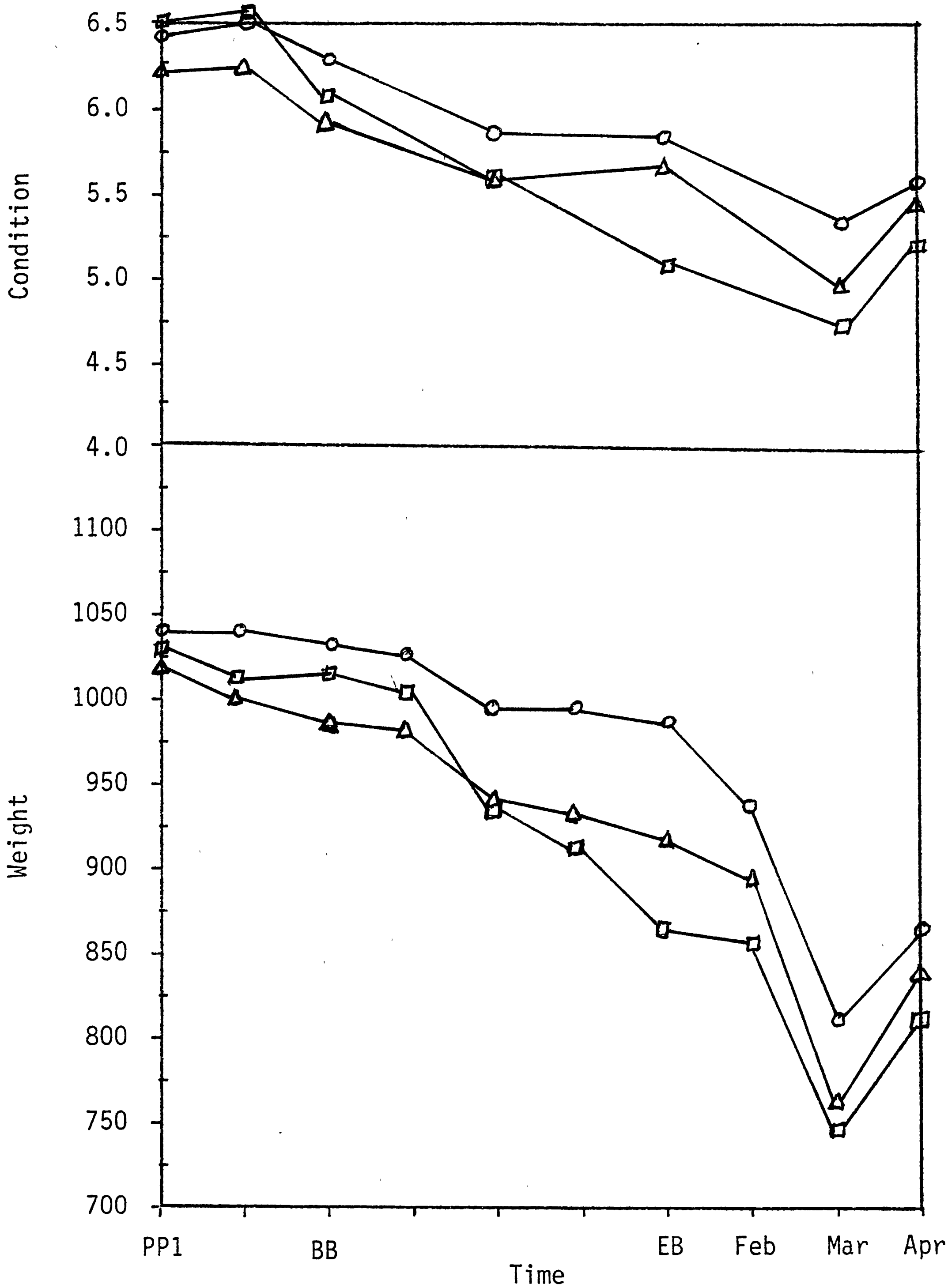

Figure 1. Cow Weight and Condition Change: Year 1.
Trt 1 (-○-), Trt 2 (-△-), Trt 3 (-□-)

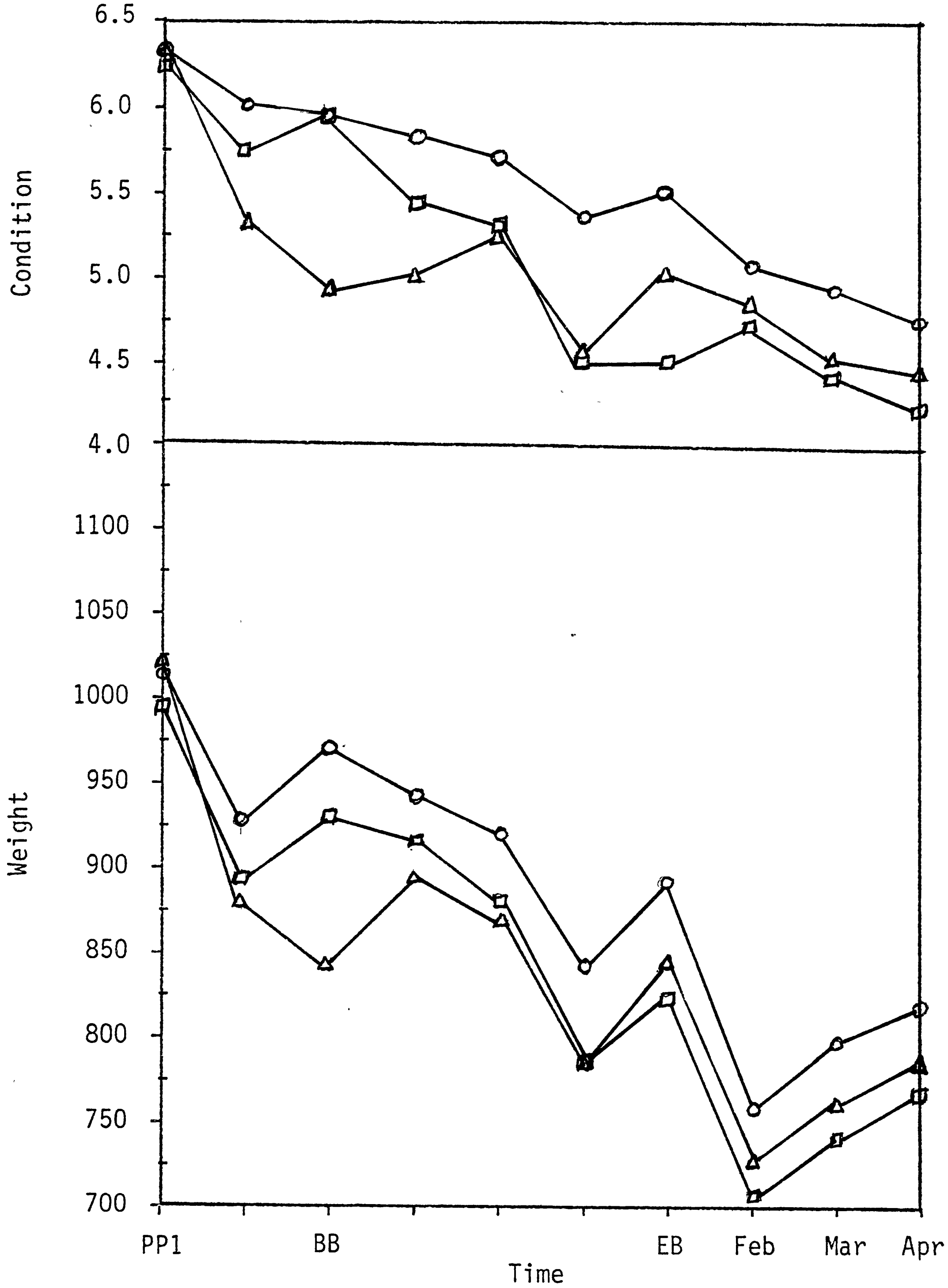

Figure 2. Cow Weight and Condition Change: Year 2.
Trt 1 (-O-), Trt 2 (-Δ-), Trt 3 (-□-)

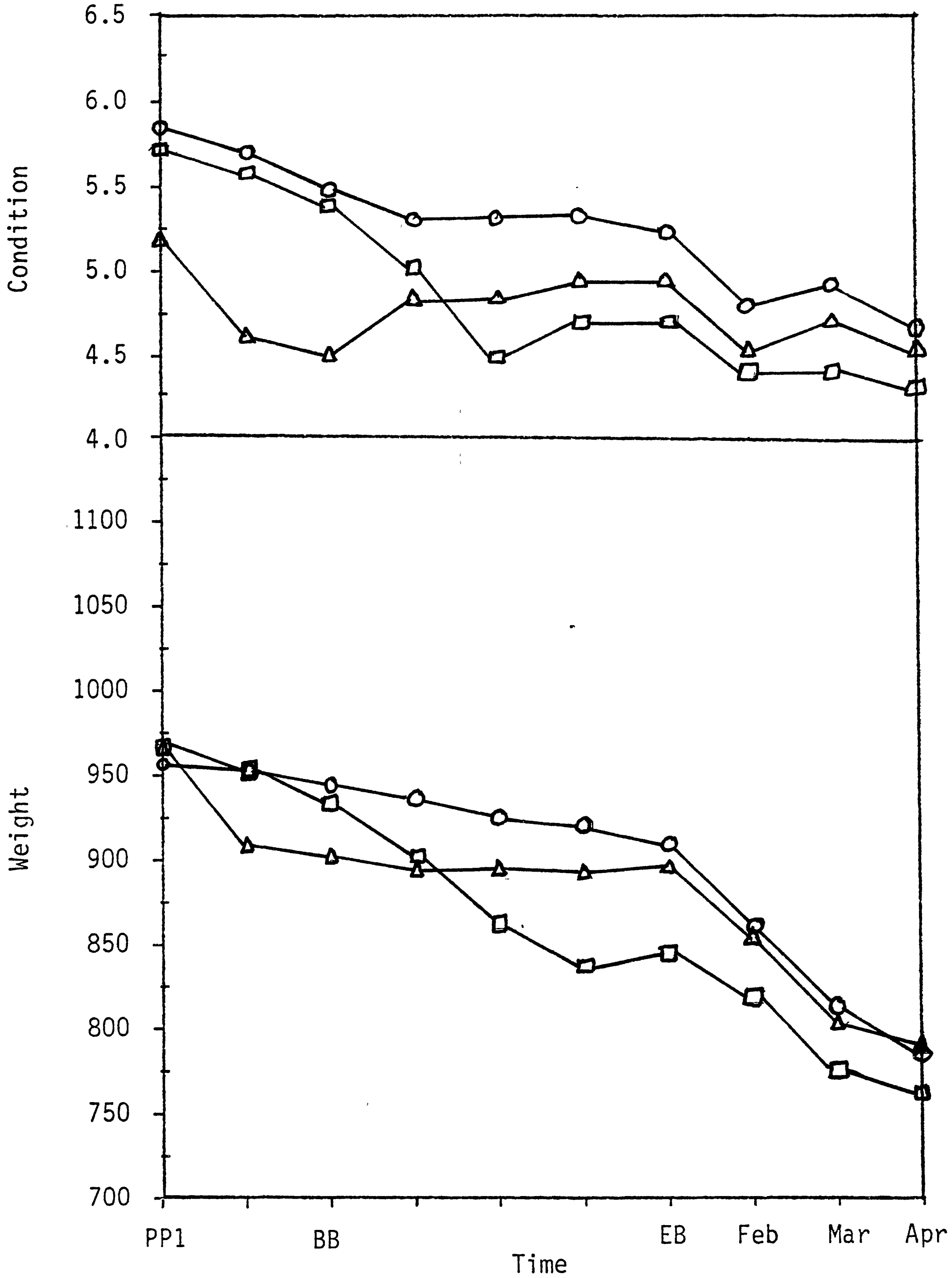

Figure 3. Cow Weight and Condition Change: Year 3.
Trt 1 (-O-), Trt 2 (-△-), Trt 3 (-□-)

VITA 2

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