PREPARTUM NUTRITION, PLASMA CONSTITUENTS

AND REPRODUCTIVE PERFORMANCE OF

RANGE BEEF COWS

By

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AND REPRODUCTIVE PERFORMANCE OF

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Scope and Method of Study: Mature pregnant Hereford cows were used to deter-
    mine the effect of supplemental feed on concentrations of protein, glucose
    and non-esterified fatty acids (NEFA) in blood plasma, hematocrit in
    blood and reproductive performance. About 120 days before calving
    (November 10), 48 cows were assigned to low supplementation (L) so that
    they would lose approximately 10% of their fall weight by calving and 18
    cows were fed moderate supplementation (M) to maintain their weight. Low
    cows were divided into three groups about 60 days before calving (nutri-
    tional change): one group (n=19) remained on the low plane of nutrition
    (LL). Another one-third (n=19) of the low cows were fed moderate supple-
    mentation (LM). The remaining one-third (n=20) of the cows were fed 166%
    of the moderate supplementation (LH). After calving, all cows received
    a moderate level of nutrition. Body weight and body condition scores
    (BCS) were taken from November 10 until April 29, and plasma samples were
    collected every two weeks during the last 60 days of gestation. Pro-
    gesterone was quantified in plasma between 15 to 85 days postpartum to
    determine onset of ovarian activity.

Findings and Conclusions: Body condition scores at calving were 6.0, 4.9, 5.1
    and 5.7 for cows on M, LL, LM and LH treatments, respectively. Treatment
    affected (P<.01) changes in body weight and BCS at 2, 4 and 6 weeks after
    nutritional changes but plasma glucose, protein and NEFA were not affected.
    Hematocrit was affected (P<.001) by treatments at 2 weeks after nutritional
    changes. Plasma NEFA were correlated (P<.05) with BCS at 2 (r=.23),
    4 (r=.41) and 6 weeks (r=.26) after nutritional change. Treatments af-
    fected BCS and hematocrit in postpartum cows after nutritional changes
    but plasma glucose, protein and NEFA were not affected. After calving,
    plasma NEFA were negatively correlated (P<.02) with changes in body
    weight and condition from 120 days before calving. Plasma protein was
    correlated (P<.02) with body weight and glucose in plasma (P<.02) before
    and after calving. Changes in body weight and condition were correlated
    (P<.002; prepartum r=.60; postpartum r=.70). Pregnancy rate was influenced
    by prepartum nutrition (84.2, 11.8, 41.2 and 61.5%, respectively for M,
    LL, LM and LH). We conclude that plasma concentration of non-esterified
    fatty acids is correlated with body condition before calving and
    negatively correlated after calving with changes in body weight and condi-
    tion from mid pregnancy.

ADVISER'S APPROVAL ___Robert P. Wettemann_____

TABLE OF CONTENTS

LIST OF TABLES

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Goodrich.

Although last in numerical order, but certainly not in priority, I wish to thank my wonderful wife, Magaly, and our son, Andres, to whom this thesis is lovingly dedicated.

CHAPTER I

INTRODUCTION

The main goal in a cow-calf enterprise is to produce
and wean a large calf every 12 months. Cow-calf enterprises
are concentrated in areas where there is an abundance of
land that is not capable of producing cash crops profitably,
because of insufficient rainfall or where management of the
land is difficult. Cattlemen use livestock to convert
range forages, pastures, and crops into meat, a high qual-
ity nutritious food for human consumption. In addition,
beef cattle require a small investment in buildings and
equipment, and little labor compared to other livestock.
However, the cow-calf program requires labor and management
of above average quality and more important, it is a year-
round operation. Cow-calf operations usually have a
limited breeding season, and a major objective is to have
a high percentage of calves born early in the calving
season. To achieve this, a cow must conceive by 80 days
postpartum in order to have a 365-day calving interval.
Since the calving interval includes the gestation period,
the interval between parturition and a new conception, cows
that fail to initiate normal estrous cycles by 80 days
postpartum cannot maintain an acceptable calving interval.

1

The number of days required by cows to conceive after parturition is one of the best criteria to evaluate reproductive ability under range conditions. This interval influences the length of the breeding season necessary to obtain a satisfactory calf crop.

Parturition is followed by a variable period when the cow is reproductively inactive. During this time, uterine involution occurs and endocrine changes occur which are necessary for the onset of ovarian activity. The duration of the postpartum anestrous interval in cows is influenced by many factors, of which the suckling stimulus, level of nutrition, body condition, changes in body weight, breed and age of the cow appear to be the most important.

In heifers, puberty is the limiting factor to the onset of reproductive function. Puberty in cattle is usually considered as the time when estrus and ovulation first occur simultaneously. Weight is a major factor that determines time of puberty. Similar factors may control the onset of ovarian activity at puberty and after calving. An understanding of the factors that regulate the length of the postpartum anestrous interval should help to increase reproductive performance in beef cows and improve the potential for profit in cow-calf programs.

The purpose of this experiment was to determine the influence of different prepartum nutritional regimes on body weight, body condition score, reproductive

characteristics, hematocrit and concentrations of glucose, proteins and non-esterified fatty acids in plasma.

CHAPTER II

LITERATURE REVIEW

Factors Affecting the Postpartum

Anestrous Interval

The postpartum anestrous interval is the period from
parturition until the first postpartum estrus that is ac-
companied by ovulation (Dunn and Kaltenbach, 1980). In
cattle, this interval varies with age and breed of the
cow, duration and intensity of suckling, environmental tem-
perature, day length, and most important, nutrition.

Age and Breed of the Cow

Age of cow may influence postpartum reproductive ef-
ficiency. Reduced conception rates and late conception
during the breeding season in 2- and 3-year-old cows ac-
count for a high percentage of the reproductive ineffi-
ciency in beef cattle (Laster et al., 1973). Fewer 2-year-
old cows were detected in estrus, conception rate was
reduced during the artificial insemination period and
intervals from calving to first estrus and from calving to
conception were longer than for 3-, 4- and 5-year-old cows.
Wiltbank (1970) observed that the average interval from
calving to first estrus was 53 days in cows 5 years of age

4

or older, 60 days in 4-year-old cows, 67 days in 3-year-old cows and 92 days in 2-year-old cows. In addition, by 80 days postpartum, 80% of the cows 5 years of age or older had exhibited estrus compared to only 68% of the 3-year-old cows. Consequently, the interval from calving to first estrus was too long to permit a 12-month calving interval in 32% of the young cows and in 11% of the older cows. Tervit et al. (1977) found a longer interval from calving to first estrus in first calf heifers (85 days) compared to 3- and 4-year-old cows (63 and 57 days, respectively). Similarly, Stevenson and Britt (1979) found a longer interval to first ovulation in pluriparous dairy cows compared to primiparous cows (18.7 vs. 16.3 days) but age did not influence the length of the interval to first estrus. Oxenreider and Wagner (1971) suggest that the marked depression in fertility in first calf heifers may be due to a combination of lactational stress, suckling of calves, a need for continued body growth and marginal nutrition intake.

Breed of cow influences the intervals from calving to first estrus and from first breeding to conception (Laster et al. 1973). These intervals were longer in Brown Swiss cows when compared with Hereford, Angus, Charolais crosses and Red Poll cows. Inskeep and Lishman (1979) reported that 2-year-old Angus and crossbred cows (crosses of Angus and Hereford with Charolais, Simmental, Brown Swiss or Holstein) rearing their first calves were more likely to

have a corpus luteum at a given stage postpartum than Herefords or various crosses of the British breeds. However, there were no breed differences at 3 years of age. Mature cows had shorter postpartum anestrus and anovulatory intervals and were reproductively active sooner after calving than 2- and 3-year-old cows. The Angus cows had shorter postpartum intervals and the crossbred cows had longer postpartum anestrous intervals than the Hereford cows. Whitman et al. (1975) did not find any effect of age or breed on the postpartum estrus and pregnancy rate in Angus and Hereford cows, but Dunn et al. (1969) observed marked differences in occurrence of estrus between Hereford and Angus cows fed low energy levels post-calving, supporting the evidence that reproductive performance of breeds may differ under a given environment. Bellido et al. (1981) observed that cow efficiency (percentage of cow weight represented by the calf weight at weaning) was greater in Angus x Hereford than in Hereford cows, which had the longer calving interval. Moreover, calves from Angus x Hereford dams were heavier than those from Hereford dams at branding and weaning (82.1 vs. 71.3 Kg. and 223 vs. 205 Kg. respectively). The most dramatic breed effects have been observed (Kaltenbach, 1980) between Bos taurus and Bos indicus, with the latter having an extended anestrous postpartum. Baker (1969) demonstrated that Bos indicus crossbred cows that were maintained in poor condition over a suckling period of 180 days had an interval of

120 days from calving until the first estrus.

Length and Intensity of Suckling

The degree of lactation stress is one of the primary factors responsible for the variation in the length of the interval from parturition to conception in cattle. The length of the postpartum interval to first estrus is directly related to the length of the suckling period (Kaiser, 1975). However, he concluded that the strength of the suckling stimulus, as controlled by the number of suckling calves, appeared to have little effect. Graves et al. (1968) observed postpartum intervals to first estrus ranging from 18 to 41 days in nonlactating cows and 53 to 93 days for lactating cows. When cows received no suckling stimulus after 30 days postpartum, they had a shorter average interval to first estrus than suckled cows (Smith and Vincent, 1972). When the mammary gland was removed prior to parturition, it shortened the postpartum anestrus interval (Short et al. 1972). Nonsuckled and suckled cows had intervals of 25 and 61 days, respectively, compared to 14 days in the mastectomized cows. Reeves and Gaskins (1981) and Randel (1981) observed similar responses when the suckling stimulus was reduced by temporary calf separation. Suckling regulates the length of the intervals from parturition until uterine involution, ovulation, estrus and conception (Oxenreider, 1968).

The effect of suckling on postpartum reproduction is

influenced by the nutritional status of the cow. The interval from parturition to ovulation was not affected by postpartum energy intake in nonlactating or milked cows (Oxenreider and Wagner, 1971). However, in suckled cows, only the cows with the high energy intake ovulated by 56 days postpartum. Randel and Welker (1977) reported that 2-year-old Brahman crossbred heifers fed a high plane of nutrition both before and after calving and suckled ad libitum had a 124-day postpartum interval to first estrus. At 180 days postpartum, 40% of the young cows did not exhibit estrus. Alternately, when the calves were allowed to nurse only once daily, the length of the postpartum interval was decreased to 32 days and all heifers exhibited estrus.

The postpartum interval to estrus and conception is positively related to suckling intensity (Wyatt et al., 1977; Dunn, 1980; Kaltenbach, 1980; Wettemann et al., 1978; Kaiser, 1975). Graves et al. (1968) suggested that the difference in the postpartum interval to first estrus between suckled and non suckled cows will likely be exaggerated since ovarian cycles in suckled cows more often will be unobserved.

Temperature and Breeding Season

The climatic environment is an important factor influencing reproduction of certain domestic animals. Christenson (1980) reported that factors which influence

heat transfer, such as air moisture content, thermal radiation and wind speed may directly affect the ability of an animal to maintain body temperature. Ambient temperature influences the endocrine system in Brahman heifers and may cause seasonal variations in sexual activity (Plasse et al., 1968). Season influenced the frequency of corpora lutea and size and tonus of the uterus. Sexual activity was increased during the spring and was greatest during the summer in Florida. After a reduction in the number of normal corpora lutea during the winter, the number of corpora lutea increased again during the second spring. However, seasonal variations in luteal function did not occur in Brahman x British heifers. Fertility of lactating Holsteins (number of live calves born per number of breedings per month) was reduced from 50% to less than 20% during the summer in Arizona (Monti and Wolff, 1974). Loyacano et al. (1972) reported a decrease in reproductive performance when cattle were bred during the hottest part of the year. Cows calving in the spring had a shorter postpartum interval to first estrus compared to cows calving in the fall (68 vs 84 days). The spring calving cows gained more weight postpartum (34 vs -8 Kg.). Early weaning of calves before a restricted breeding period may provide an effective management practice to increase reproductive efficiency (Bellows et al., 1974; MacPherson et al., 1976; Lusby et al., 1981; Laster et al., 1973). Edgerton (1980) suggested that release of gonadotropins from the pituitary is

inhibited during lactation. Suckling may influence the size of the corpora lutea (Riesen et al., 1968), concentration of progesterone in plasma (Chang et al., 1981), concentration of cortisol in plasma (Wagner and Oxenreider, 1972) and onset of ovarian cycles (Radford et al., 1978).

Many factors may influence the effect of season on reproductive performance. Climatic effects on fertility may not be as apparent or may even be opposite from expected when nutrients available to the animal are seasonally controlled.

When climatic factors such as maximum temperature or solar radiation were taken into consideration, month to month differences in conception rates no longer occurred (Thatcher, 1974). In addition, uterine temperature was associated with fertility because a rise of 0.5 C above mean uterine temperature on the day of or day after insemination resulted in decreased conception rates.

Day length is associated with fertility in cattle. Mercier and Salisbury (1947) observed reduced breeding efficiency during winter when duration of daylight (photoperiod) is short. The percentage of successful services was lowest during winter and spring and highest during summer and fall. In two experiments, with suckled and non-suckled cows, Hansen and Hauser (1983) reported that animals that calved in winter had longer intervals from parturition to first estrus than those that calved in summer. Differences between seasons tended to be greater for suckled cows,

cows with genetic ability for high milk production, primi-
parous cows and cows fed diets low in energy. Harrison
et al. (1982) indicated that environmental phenomena occur-
ring in the period between the shortest and longest day of
the year exert their greatest effects in Brahman on endog-
enous release of LH and progesterone between January and
March. The number of cows with LH surges, the overall LH
profile and luteal phase progesterone concentration were
all significantly changed during January to March, and
further changes between March and June were minimal. The
influence of photoperiod on reproduction in other breeds of
cattle is not clear.

<center>Influence of Nutrition on Reproduction</center>
<center>in Beef Cows</center>

Nutritional deficiencies are frequently associated with
infertility in cattle. However, it is very difficult to
evaluate the effect of a specific nutrient on fertility
because, generally, the ration is deficient in more than one
nutrient and utilization of one nutrient is usually dependent
on availability of other nutrients and the clinical signals
vary depending on the degree of the deficiency. Dunn (1980)
indicated that the most critical period of time in the pro-
ductive life of the beef female is the last trimester of
gestation plus the first 60 days of lactation. Malnutrition
during the last trimester of gestation can be particularly
detrimental because fetal growth is greatest at this time

and severe deficiencies may cause neonatal mortality. In addition, cows which are not in good condition at calving usually have an extended interval from calving to the first postpartum estrus. Whitman et al. (1975) observed that changes in nutrition both before and after calving had a dramatic effect on the length of the interval between calving and the first postpartum estrus. Energy intake before calving appeared to be more important than intake after calving (Wiltbank et al., 1962). When energy was limited during the prepartum period, the interval from parturition to first estrus was increased and weight and condition of the dam, birth weight of the calves, number of cows exhibiting estrus and pregnancy rate were decreased (Bellows and Short, 1978; Wiltbank et al., 1962; and Donaldson et al., 1967). Moreover, when the condition of the cow at calving was poor, the interval to first estrus was significantly increased (Whitman et al., 1975). Restricted energy intake after calving results in reduced conception rates (Somerville, 1979; Davis et al., 1977; and Donaldson et al., 1967). Wiltbank et al. (1962) reported that the postcalving energy intake was specially important in those cows which had reduced energy intake prior to calving. The effect of reduced energy intake prior to calving was not readily overcome even though the cows received extra energy after calving.

The amount of energy that a cow consumes may also affect estrous cycles. If cycling heifers were fed reduced

energy intake, the number of medium-sized ovarian follicles is reduced, estrous cycles are longer and a lower proportion of the heifers had normal fertilized ova (Hill et al., 1970). Wagner and Oxenreider (1971) also reported delayed growth of ovarian follicles when energy intake was restricted and Gombe and Hansen (1973) observed ovarian hypofunction.

The lack of ovarian activity in cows fed reduced energy intake may result from a lack of release of gonadotropins from the pituitary or lack of production of gonadotropic hormones, or both, rather than a decrease in sensitivity of the ovary (Wiltbank et al., 1962; Gombe and Hansel, 1973). Joubert (1954) observed that the plane of nutrition did not influence cycle length.

Protein intake may also affect the reproductive performance of cows although it is usually difficult to determine if the effect of supplemental protein is due to the protein fed or the additional energy. Donaldson et al. (1967) reported an increased calving percentage and decreased interval from parturition to first estrus when cows were fed a protein supplement in the winter. However, Treacher et al. (1976) reported significantly better fertility in cattle fed less than the recommended amount. Sorghum grain (1.4 Kg/day) was a superior supplement to soybean meal (.7 Kg/day) in improving weaning weight and reproduction when fed with 1.4 Kg. alfalfa hay/day (Davis et al., 1977). Energy reserves or body condition of the cows may influence the results observed when cattle are fed supplemental protein.

Influence of Nutrition on the

Onset of Puberty

Puberty is generally defined as the time when first
estrus and ovulation occur simultaneously. At this time,
the female is capable of reproducing the species. Growth
rate or feed intake is related to the age at puberty in
cattle. Dunn (1980) suggested that two limiting factors
within each breed which determine the occurrence of puberty
are weight and age. No matter how old a heifer is, puberty
will not occur until the animal attains a certain minimal
weight. Reproductive performance of heifers can be increased
if they are bred early in the first breeding season (Wiltbank,
1970). To accomplish this, heifers must reach puberty at
13 to 14 months of age and breed successfully at their first
or second estrus. Restricted energy intake after weaning
significantly delays the onset of puberty in heifers (Morrow,
1980; McClure, 1968; Reid, 1960; Joubert, 1954). When dairy
heifers were fed at the rate of 62, 100 or 146% of recom-
mended TDN, the onset of puberty occurred at 20, 11 and 9
months, respectively (Morrow, 1980). Heifers weighed ap-
proximately 600 pounds at the onset of puberty, suggesting
that body weight is more important than age in determining
the time of first estrus. The influence of different rates
of gain on pubertal development is influenced by breed.
Reed (1960) accelerated the age at puberty by a greater
intake of energy (279 days) when compared to medium (337

days) or low (616 days) intakes of energy. Once estrous
cycles were initiated, they occurred with equal regularity
in heifers fed the different amounts of energy, though the
cessation of estrous cycles can be affected by severely
restricting the energy intake of heifers previously fed
adequate diets (Bond et al., 1958).

When Holstein heifers were fed extra amounts of grain
from 2.5 months of age to initial breeding size (120 cm.
withers height) they exhibited first estrus at an earlier
age (7.5 ± .1 months) compared to control heifers receiving
a standard amount of grain (8.7 ± .2 months) (Pritchard et
al., 1972). Neither pituitary LH nor FSH was influenced by
quantity of grain fed.

Effect of Weight Changes
on Reproduction

The resumption of postpartum ovarian activity is large-
ly affected by weight changes of the cow before and after
calving. Weight changes pre and postcalving significantly
affect the likelihood of the first estrous at 40-50 days
postpartum (Whitman et al., 1975). Dunn and Kaltenbach
(1980) indicated that a negative prepartum weight change
means that the cow utilized her body tissue stores to provide
nutrients for the developing conceptus. A positive prepartum
weight change indicates that the cow consumed sufficient
nutrients to meet the demands of maintenance plus growth of
the conceptus. As a consequence of weight loss prepartum

(Bellows et al., 1974; Corah et al., 1975; Dunn et al., 1969), the fetus is smaller at birth and weaning weights are reduced. In addition, the rate of gain from birth to weaning was less for calves from mothers that lost excessive amounts of body weight during the last trimester of gestation. The continued decline in body weight over 10 weeks after calving indicates the necessity to catabolize body tissues to maintain milk production (Downie and Gelman, 1976). Cows with restricted feed intake during early lactation should have sufficient body tissue at calving to allow for compensatory metabolic adjustments during early lactation to ensure that milk production can occur without influencing ovarian activity. Mobilization of depot fat has been considered essential for maintenance of lactation (Bowden et al., 1979; Broster, 1963; Lowman et al., 1979). Dunn et al. (1969) suggested that the pregnancy rate at 120 days after calving appeared to be related to postcalving weight gains since cows given low energy before and high energy after calving had the greatest postcalving gains and also had the greatest pregnancy rate. In contrast, high energy before calving and low energy postpartum resulted in weight loss after calving and a greatly reduced pregnancy rate.

There is a negative relationship between the length of the postpartum interval to first estrus and prepartum weight changes (Dunn, 1980). The predicted length of the postpartum interval was 47 days for cows that had no prepartum weight change. The postpartum interval to first estrus was

predicted to increase 0.17 days with each kilogram of negative weight change. Thus, cows that lost 120 Kg. prior to calving would be expected to have a 67 day postpartum interval. Corah et al. (1975) reported that cows fed a restricted intake of energy (50% of the NRC recommended value) during 100 days prepartum lost 65 Kg; when half of the cows were supplemented (117% of the NRC recommended value) starting 30 days prior to calving, the weight loss was only 10 Kg. Calves from supplemented cows were heavier at birth, more viable, and heavier at weaning than calves from the cows in the restricted energy group.

Changes in weight of the fetus confuse the interpretation of changes in the body weight of the female (Bowden et al., 1979). Thus, in the pregnant animal, the nutrient adequacy should be considered not only on the basis of weight changes but also on changes in body condition or possibly blood constituents.

<div align="center">

Effect of Body Condition on

Reproductive Performance

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Body weight change in cattle is often used as a guide to estimate body condition. However, body weight is influenced by gut fill and the weight of the conceptus in pregnant cows. Since body condition score is a reliable measure of the energy reserves in the body, animals with identical live weights and different frame sizes may have different body condition and animals with identical body

condition may have different body weights.

Body condition of the cow at the moment of calving affects the length of the postpartum anestrus interval. A high percentage of cows in good body condition at parturition exhibited estrus by 60 days postpartum regardless of weight changes either before or after parturition (Dunn and Kaltenbach, 1980). Thus, the response to prepartum weight changes seems to depend on the body condition of the cow at parturition. If the plane of nutrition following calving is increased, it has little influence on the length of the postpartum interval if cows are thin at calving time (Dunn, 1980). Thus, it appears that a cow must have a minimal amount of energy reserves before normal estrous cycles will be initiated after calving. Donaldson et al. (1967) reported that cows in poor body condition had a pregnancy rate of 10%, which was significantly lower compared to cows in good (88%) and moderate (64%) body condition. Cows in moderate and thin body condition exhibited estrus by 60 days postpartum if the cows had gained weight prior to calving compared to those that lost weight prior to calving (Dunn and Kaltenbach, 1980). Similarly, Whitman et al., (1975) reported that weight changes pre and post calving significantly affected the occurrence of estrus by 40 to 50 days postpartum. In addition, cows in good condition and gaining weight precalving had a greater incidence of estrus postpartum than cows in thin condition.

Conception rate may be reduced if cows that are in good

body condition at calving lose weight after calving (Wilt-bank, 1970). Conception rate at first service may be improved if cows that are thin at calving make rapid weight gains before breeding. Postpartum weight gains are essential for good rebreeding if cows are thin at calving and have lost weight prior to calving (Dunn and Kaltenbach, 1980). Only 25% of the thin cows that lost weight both before and after calving had exhibited estrus by 60 days postpartum. The percentage in estrus was increased to 46% in thin cows that lost weight prior to calving but gained weight after calving. Dunn and Kaltenbach (1980) suggested that the postpartum anestrous interval would be expected to increase about 1 day for each 5 Kgs. of negative prepartum weight change.

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Physiological Changes Preceding the

Resumption of Ovarian Activity

and Estrus

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Following parturition, a period of anestrus of variable length occurs. This anestrus condition is a result of the lack of follicular and luteal development. The reduced follicular growth and maturation probably is caused by decreased secretion and/or synthesis of gonadotropins (Wettemann, 1980). Pulsatile secretion of luteinizing hormone (LH) is a prerequisite for the onset of ovarian cycles (Humphrey et al., 1976; Goodale et al., 1978; Stevenson and Britt, 1979), and there is a correlation

between pulse LH frequency and the time to the first increase of progesterone in plasma after calving (Peters et al., 1981). In ewes, the combined patterns and amounts of estradiol plus progesterone secreted are both necessary and sufficient to account for the occurrence of estrus (Karsh et al., 1977).

In cattle, maturation of the ovum and ovulation are stimulated by the release of adenohypophyseal gonadotropic hormones in response to the secretion of releasing factors by the hypothalamus. Saiduddin et al. (1968) found little ovarian activity on the day after calving, but considerable activity by day 10 following calving. Ovarian follicular activity contributes an increase in concentration of estrone in plasma with each wave of follicular development (Humphrey et al., 1983). The estrogens probably alter the function of the hypothalamus and cause increased LH secretory activity. The pulsatile secretion of LH sensitizes the ovary for a period of 2 to 3 weeks with subsequent ovulation or luteinization of a follicle. These events result in an increase in peripheral concentration of progesterone for 4 to 5 days (Kaltenbach, 1980). The progesterone alters hypothalamic function and possibly leads to an increase in secretion of gonadotropins, which results in follicular growth culminating in ovulation and a normal cycle.

The variability in the length of the interval to first ovulation is less than that for the interval to first estrus (Baker, 1969). The great amount of the variation in the

interval to first estrous could be due to variation in the
number of ovulations without the expression of estrus. The
high incidence of ovulation without estrus early in the
postpartum period may be the result of a failure to detect
short or weak estrual periods rather than the lack of expres-
sion of estrus (Short et al., 1972). Reestablishment of
estrus activity following parturition is preceded by the
resumption of follicular development (Saiduddin et al.,
1968). In addition, the expression of estrus may follow
quickly or there may be a period of follicular atresia or
even one or more ovulations before a normal estrus. Forty
seven percent of the Holstein cows ovulated without expres-
sion of estrus. But, only 47% of the cows bred at the first
estrus following parturition conceived, compared to 69% of
the cows bred at the first estrus after 74 days postpartum
(Saiduddin et al., 1968). Marion and Gier (1968) observed
that of 86% of the dairy cows which ovulated during the
first 20 days postpartum, only 5% had exhibited estrus. The
corpora lutea that resulted from ovulations during that
period failed to develop to normal size and had shorter
lifespans than corpora lutea of normal length estrous cycles.
Shorter estrous cycles immediately after parturition were
observed in high producing cows (Morrow et al., 1966). The
occurrence of ovulation without behavioral estrus (silent
estrus) was greatest at the first postpartum estrus and
declined with each succeeding estrus in cattle and the oc-
currence of silent estrus was greater in younger cows than

in older cows.

Regression of the corpus luteum of pregnancy does not affect resumption of ovarian activity. Postpartum anestrous is not a result of the maintenance of the corpus luteum of pregnancy (Labhsetwar, 1964) and uterine involution was not affected by ovariectomy or by removal of the corpus luteum of the previous pregnancy within 4 days after calving (Oxenreider, 1968). Morrow et al. (1966) observed that 62.5% of normal corpora lutea, which regressed early in the postpartum period, did not prevent the onset of estrus. The presence of a corpus luteum on the ovary was usually indicative of a normal estrus cycle and was not a retained corpus luteum. Oxenreider (1968) observed that the presence of a regressing corpus luteum in addition to developing follicles may lead to the expression of behavioral estrus in postpartum suckled cows. Kiracofe (1980) suggested that the possible depression in conception rate at the first estrus postpartum may be due to formation of abnormal corpora lutea and failure to maintain luteal tissue rather than delayed uterine involution. Under normal conditions, the involuting uterine only appears to be a contributing factor to lowered fertility for approximately 40 days postpartum.

Blood Constituents During Gestation
and the Postpartum Period

Change in body weight is often used as the criterion for measuring nutrient adequacy. However, in the pregnant

animal, changes in weight of the fetus may confuse the inter-
pretation of changes in the body weight of the female. Since
most physiological processes involve transport of metabolites
by the blood, changes in rates of biochemical processes may
be related to certain blood constituents. Nutrient intake is
associated with variation in the metabolism of fat in the
body, especially mobilization of depot fat during low in-
takes. Related to this process are changes in non-esterified
fatty acids (NEFA) and blood glucose. As a measure of energy
status, plasma concentrations of glucose and NEFA may be use-
ful and total protein in plasma may be an indicator of pro-
tein status of an animal.

Blood Glucose

Ruminants use fiber as an energy source. This fiber is
composed of mainly cellulose and polysaccharide formed by
condensation of glucose units into long chains. However,
when cellulose is digested by the rumen microbes, the major
products are the volatile fatty acids. Most of the vola-
tile fatty acids produced are absorbed directly through the
rumen wall and in tissues cattle convert propionate into
glucose. Ruminants suffer from a shortage of glucose,
particularly during periods of high metabolic activity,
since glucose is an essential metabolite for some tissues
(Church, 1979). Concentrations of glucose in blood are
normally less in ruminants than in monogastric species.
Prefeeding concentrations of glucose in whole blood in

adult nonpregnant ruminants are generally between 35-45 mg/ 100 ml. Ruminants are also unusual in that their red cells contain virtually no glucose and prefeeding plasma glucose values are between 55-65 mg/100 ml. This value reflects the point of balance between glucose input into the plasma (derived from gluconeogenesis and glycogenolysis) and glucose uptake by the tissues.

Concentrations of glucose in blood are indicators of the carbohydrate status of the animal, and mean blood glucose concentration for a herd of cows is informative since all hypoglycemic herds do not exhibit dramatic clinical signs (King, 1971). Cows with reduced blood glucose can suffer from anestrus, particularly during the winter. In addition, blood glucose concentration at mating of infertile dairy cows was decreasing and reduced when compared to those of fertile cows. Cows losing body weight at more than 1% per week had concentrations of glucose in blood of 28 mg/ 100 ml and a first service pregnancy rate of 16%. Cows in the same herd that were supplemented with concentrate and lost little weight had a mean glucose concentration of 39 mg/100 ml and a pregnancy rate of 90% (McClure, 1970).

When low energy diets are given to cows, body reserves of energy are mobilized and loss of weight occurs. If gluconeogenesis is inadequate, hypoglycemia occurs and hypothalamic failure and infertility may follow. Downie and Gelman (1976) observed that an increased rate of weight loss coincided with decreases in plasma glucose and

infertility in cows. When body weight was adjusted to a lowered nutrient intake and plasma glucose was increasing, cows had a higher incidence of fertile heats. Increased glucose concentrations at 20 days before estrus were associated with fertile matings regardless of body weight changes. Horrocks and Paterson (1957) found that glucose concentrations increased just before parturition with a steady decrease to a lower concentration after parturition. In addition, there was a significant decrease between the first and second weeks postpartum.

Insulin induced hypoglycemia in lactating cows at 3 or 4 days before expected estrus depressed the incidence of estrus and pregnancy rate (McClure, 1968). It is possible that the infertility caused by reduced nutrient intake may be linked to a hypothalamic failure to control the adenohypophysis as the direct consequence of failure of the hypothalamus to be supplied with or utilize glucose. Howland et al. (1966) suggested that since brain tissue function depends on glucose for its energy source, even mild hypoglycemia may depress hypothalamic function, thus resulting in a loss of ovarian activity.

A syndrome of infertility in cattle has been reported in Australia and New Zealand (McClure, 1968). It is characterized by reduced first service non-return rate, a high proportion of non-pregnant cows at 3 months after the first service, a high proportion of weight loss between parturition and mating and low concentrations of glucose in blood

(below 30 mg/100 ml and down to 20 mg/100 ml) in the infertile cows at about the time of mating. The relation between blood glucose and fertility suggests that some bovine infertility may be the result of hypoglycemia. In agreement with this finding, plasma glucose concentrations for the 56 days postpartum were negatively correlated with the interval from parturition to the presence of a 10 mm. follicle (r = -.50) and first ovulation (r = -.62) (Oxenreider and Wagner, 1971). In addition, lactation and decreased energy intake postpartum had a depressing effect on plasma glucose and body weight. Both factors affected the interval from parturition to the development of a follicle greater than 10 mm. in diameter and ovulation.

Plasma Proteins

Quantitatively, dietary protein is required by ruminants in amounts second only to energy. Once protein has been ingested and digested, the end products, amino acids, are utilized for synthesis of tissues and secretions. In addition to these important functions, plasma proteins perform a number of enzymatic functions in the plasma and can act as a source for rapid replacement of tissue proteins. Plasma proteins function as labile proteins in storage medium and represent a rapidly available source of amino acids whenever a particular tissue requires them. The concentration of protein in blood plasma of cows is about 7%, represented mainly by albumin (4.5%) and globulins (2.5%).

Variations in the concentration of protein in plasma around the time of parturition have been observed in cows. Larson and Kendall (1957) found a decrease in blood serum proteins 4 weeks before parturition, and the decrease was associated with a diminution in the concentration of globulins. Plasma protein was greatest at the onset of pregnancy and then decreased until parturition. King (1971) observed increased concentration of proteins in plasma throughout the postcalving period, from 6.9 mg% just before calving to 7.4 mg% at 14 weeks after calving. Feeding cows either low or high protein diets from 8 weeks precalving until 14 weeks postcalving did not alter total protein or globulin in plasma (Treacher et al., 1976). Patil and Deshpande (1979) and King (1971) observed increased conception and estrous rates when plasma proteins were increased in cows.

Non-Esterified Fatty Acids

The first stage in the utilization of triglycerides for energy purposes is the hydrolysis into fatty acids and glycerol. These products are transported to tissues where they are oxidized to produce energy. On leaving the fat cells, fatty acids ionize strongly in the plasma and combine with albumin. These fatty acids bind to plasma proteins and are called free fatty acids or non-estrified fatty acids (NEFA) to distinguish them from the long-chain fatty acids present in the esterified form in neutral fats or phospholipids (Patterson, 1963). Wertheimer and Shafrir (1960)

suggested that concentrations of NEFA in plasma reflect the extent of body fat utilization. The concentrations of NEFA in plasma increase promptly whenever energy must be utilized from stored fat as in fasting and concentrations of NEFA decrease when normal carbohydrate utilization starts. Plasma NEFA concentrations in cows are usually between 1000-2000 µeq/liter, but are reduced under non-fasting conditions (200-300 µeq/liter; Radloff et al., 1966). Bowden (1971) indicated that in cattle, concentrations of 1000 µeq/liter or more of NEFA in plasma represent an increase in mobilization of depot fat. Under fasting conditions, plasma NEFA concentration increases to values of 1500-2500 µeq/liter. Similar concentrations were found in ewes (Annison, 1960) during pregnancy and in nonpregnant fasted animals. However, Patterson (1963) observed that fed animals always had reduced plasma NEFA values compared to starved animals.

Many hormonal effects on fatty acid metabolism are mediated via action on NEFA release from adipose tissue, thereby controlling plasma NEFA concentrations (Fritz, 1961). Plasma NEFA values are affected by glucose as well as hormones. Epinephrine is one of the most potent factors eliciting increased NEFA release (Wertheimer et al., 1960). Kronfeld (1965) found that epinephrine was able to increase NEFA concentrations from values of less than 200 µeq/liter to more than 400 µeq/liter within 10 minutes. Insulin administration depressed NEFA release in vitro and

in vivo (Engel and White, 1960). Insulin increases glucose utilization via all available pathways, including formation of triglyceride fatty acid. Wertheimer and Shafrir (1960) reported that insulin markedly increased lipid synthesis in the presence of glucose.

Intravenous injection of insulin caused an initial decrease in the concentration of NEFA in plasma, followed by a rapid increase which was presumably a response to reduced concentration of blood sugar. Annison (1960) observed that elevated concentrations of NEFA were maintained throughout hypoglycemia. Injection of glucose reduced NEFA concentrations to values of 50 µeq/liter (Fritz, 1961). Enhanced glucose utilization increased glyceride synthesis and decreased NEFA values in adipose tissue. Increased glyceride synthesis results in decreased rates of fatty acid oxidation by all tissues and in diminished rates of NEFA release by adipose tissue.

Other factors affecting concentration of NEFA in plasma of ruminants include pregnancy and lactation (Bowden, 1971), cold exposure, animal handling (Halliday et al., 1969), time of feeding (Annison, 1960; Radloff et al., 1966; Kronfeld, 1965), type of ration (Annison, 1960), digestible energy intake and mild excitement (Holmes and Lambourne, 1970).

Hematocrit

The percentage of blood that is composed cells is

called the hematocrit or packed cell volume. Values for humans are about 40%, while the hematocrits for bovines average about 33% (Treacher et al., 1976). Hematocrits vary tremendously, depending upon whether or not the animal has anemia and the degree of body activity. Holmes and Lambourne (1970) observed that packed cell volume was inversely related to plasma volume. When cows were fed either less or more than the recommended intake of protein from 8 weeks precalving until 14 weeks postcalving, packed cell volume, red cell count and hemoglobin were all within the accepted normal range (Treacher et al., 1976). However, in situations of chronic protein deficiency, changes in amounts of hemoglobin and packed cell volume may not occur for several weeks.

Concentration of Hormones in Plasma
During the Postpartum Period

There are many dramatic changes in the concentrations of hormones in the cow before and after parturition. Some of these changes are necessary for the resumption of ovarian activity.

Prolactin is a hormone of particular interest because it has antigonadotrophic effects in some species. Lactation and suckling stimulate prolactin release (Graves et al., 1968; Baker, 1969; Koprowski and Tucker, 1973, and Chang et al., 1981). Riesen et al., (1968) found a reduced pituitary content of prolactin in postpartum suckled cows

compared to non-suckled cows. Increased plasma concentration of prolactin markedly affects resumption of gonadotrophin secretion activity, reducing pituitary stores of both FSH and LH in the cow (Baker, 1969). However, a relationship between prolactin in plasma and reproductive endocrine function in cows is uncertain (Riesen et al., 1968; Edgerton and Hafs, 1973). Williams and Ray (1978) were not able to advance postpartum reproductive activity in heifers by prolactin suppression and Kaltenbach (1980) did not find any particular role for prolactin regarding the onset of postpartum estrus. Removal of the suckling stimulus increased pulsatile LH release (Walters et al., 1982). This factor may be responsible for the increase in follicular LH receptor concentration found in cows after the calves are weaned. These events were followed by a spontaneous ovulatory surge of LH and, presumably, ovulation.

Suckling may prolong the postpartum anestrus interval in cows by reducing the frequency of pulsatile GnRH release from the hypothalamus. Most of the cows that failed to experience estrus in response to an injection of estradiol benzoate at about 6 weeks postpartum may have a malfunction of the hypothalamic mechanism, normally responsible for the establishment and maintenance of cyclic ovarian function (Radford et al., 1978).

Progesterone

Following ovulation, the granulose cells of the

follicle develop into luteal cells that secrete progesterone. Blood concentrations of progesterone are good indicators of luteal function during the postpartum period (Wettemann, 1980). Arije et al. (1974) observed that progesterone declined gradually from 10 ng/ml at 3 weeks prepartum to about 2 ng/ml at parturition. Smith et al. (1973) reported 7.6 ± .9 ng/ml of progesterone in plasma 2 days before parturition, 3.0 ± .7 ng/ml at 1 day before calving and .6 ± .1 ng/ml at parturition. Right after calving, progesterone concentration was less than 1 ng/ml (Arije et al., 1974 and Smith et al., 1973). An increase in progesterone in plasma for 4-5 days occurs just prior to the onset of the first postpartum estrus (Humphrey et al., 1976). Stevenson and Britt (1979) observed that progesterone was increasing in plasma 2 to 3 days after ovulation with an average concentration of 3.6 ng/ml. Progesterone concentrations during the postpartum period (parturition through 18 days postpartum), preestrus period (-18 through 0 days in relation to first estrus), preestrus peak (-3 days before estrus) and preestrus (-1 and 0 days preestrus) averaged .5, .25, 1.8 and .3 ng/ml, respectively (La Voie et al., 1980).

Stevenson and Britt (1979) observed that the maximum concentration of progesterone during the first cycle was decreased when compared to those observed during the second cycle, suggesting that corpus luteum function and progesterone feed back on gonadotrophin secretion may not be

fully established following the first ovulation postpartum.
Pope et al. (1969) reported that the mean maximum pro-
gesterone value during the 10 days preceding ovulation with
estrus was much greater than in the same period before
ovulation without estrus. Dairy cows that conceived after
one insemination had significantly greater progesterone
values during the estrous cycles preceding insemination
(Folman et al., 1973). A progesterone implant combined
with injections of FSH plus progesterone and an injection
of estradiol at 30 days postcalving increased the ovarian
activity in suckled cows, thus returning these cows to a
more normal endocrinological balance sooner than the un-
treated cows (Smith and Vincent, 1972).

Estrogens

Estrogens of ovarian or placental sources may affect
the length of the postpartum anestrous interval in the cow.
Wettemann (1980) suggested that hypothalamic and pituitary
function are influenced by prepartum increases in plasma
estrogens which may alter gonadotrophic secretion during
the postpartum period. A ten-fold increase in estrone and
estradiol in serum during the last month of gestation was
the first major change in steroid hormones in advance of
parturition (Smith et al., 1973). Estradiol in serum in-
creased linearly from 32 ± 7 pg/ml at 26 days before partu-
rition to 150 ± 24 pg/ml at 5 days, and increased further
to 295 ± 53 pg/ml at 1.5 to 2 days prepartum. Then,

concentration of estradiol decreased to 52 ± 11 pg/ml by
day 1 postpartum and averaged 14 ± 10 pg/ml between days
2 and 9 postpartum. Echternkamp and Hansel (1973) also
reported elevated concentration of estradiol in plasma at
parturition as compared to 4 days postpartum. Besides,
they suggested that elevated estrogen titres 2 to 3 days
before estrus may trigger the preovulatory LH release.
Humphrey et al. (1983) suggested that the onset of pulsa-
tile LH secretory activity before the first postpartum
ovulation appears to be triggered by estrone. An increase
in estrone in plasma was observed 13 days after parturition
and it was followed by an increase in LH secretory activity
in cows with postpartum intervals less than 50 days while
cows with postpartum intervals of 70 days did not respond
to the increase in estrone.

Luteinizing Hormone (LH)

Luteinizing hormone has a very important role in the
onset of postpartum ovarian activity and is involved with
final follicular growth and ovulation. Peripheral concen-
trations of LH after parturition are initially very low
and are followed by a period of intense secretory activ-
ity that lasts for 2 to 3 weeks (Gonzalez-Padilla et al.,
1975). Edgerton and Hafs (1973) observed that serum LH
remained near .5 ng/ml until parturition, then increased
an average of 1.5 ± .3 ng/ml at 5 to 6 weeks postpartum.
About a week prior to estrus and ovulation there was an

abrupt decrease in the frequency and magnitude of LH secretory peaks, which was immediately preceded by a transitory elevation in progesterone (Gonzalez-Padilla et al., 1975). Stevenson and Britt (1979) found that the number of episodic LH peaks and average LH concentrations in blood samples collected on days 7 and 14 after parturition were inversely associated with interval to first ovulation in dairy cows. Cows ovulating in the first 14 days postpartum had more LH peaks and increased average LH values on days 7 and 14 when compared to cows ovulating at 15 and 20 days postpartum. However, Peters et al. (1981) found no correlation between mean LH concentrations and onset of ovarian activity in dairy cows. They suggest that although the appearance of episodes of LH secretion does not necessarily reflect the imminent resumption of ovarian cycles, it is a potent initiator of the first postpartum follicular phase.

Suckling affects LH secretory activity. Weiss et al. (1976) suggested that lactation may selectively inhibit pituitary LH synthesis. Short et al. (1974) and Saiduddin et al. (1966) also observed the effect of suckling on concentration of LH in plasma and the presence of corpora lutea, respectively. Carruthers et al (1980) suggested that suckling prolongs the postpartum anestrous interval and anovulation by reducing frequency and perhaps amplitude of GnRH secretion. As a consequence of reduced GnRH secretion, GnRH "self-priming" is reduced, which decreases the releasable pool of LH in the pituitary and frequency and

magnitude of episodic LH release. The end result of the
suckling-induced reduction in episodic LH secretion is a
delay in ovarian follicular maturation and prolongation of
the postpartum anovulatory interval.

Restricted intake of energy reduced concentrations of
LH in plasma and reduced the sensitivity of the ovaries to
LH (Apgar et al., 1975). LH stimulated progesterone pro-
duction by corpora lutea in vitro from cows receiving ade-
quate (100% TDN) and restricted levels of intake (60% TDN).
The increase in progesterone was less, however, in the cows
receiving restricted TDN, particularly at the greatest
amount of LH. When 0, 100 or 200 µg of GnRH were given to
suckled cows at 3 and 5 weeks postpartum, serum LH responses
did not differ between cows given 100 or 200 µg GNRH
(Wettemann et al., 1982 and Fonseca et al., 1980). More
estrous periods were detected in GnRH treated cows 20 days
after treatment, and treatment with GnRH tended to increase
the percentage of anestrous cows which ovulated by 8 days
after treatment (Fonseca et al., 1980). GnRH treatment
may be useful to initiate estrous cycles in anestrous cows
that are almost ready to initiate cycles. However, this
therapy is not successful in underfed cows and in cows in
thin body condition.

Changes in Body Weight, Plasma
Constituents and Reproduction

Nutritional deficiencies play significant roles in

the malfunction of the reproductive system. Changes in the nutritive value of forages, associated with seasonal variations, are important in determining if nutrient requirements of the cow are met.

During the fall and winter seasons, nutrient requirements for gestating and lactating cows are increased and the nutrients available from pastures are diminished. For instance, supplemental feeding regimes are necessary to avoid weight losses, which reduce considerably the body condition of the animal. Lowering energy intake below maintenance requirements results in a decrease in body weight, accompanied with a decrease in concentrations of glucose in plasma (Downie, 1976). Rasby et al. (1983) reported increased plasma glucose and proteins when range cows were fed a high level of supplemental grain after limited feeding compared to cows maintained on a low level. Patil and Deshpande (1979) demonstrated that when body weight losses after parturition were greater than 2%, blood glucose and plasma protein concentrations were significantly reduced compared to cows gaining weight during the same period. These observations suggest that plasma metabolites, especially glucose, are closely related to body weight and body condition changes. When body weight and plasma glucose were decreasing, cows were less fertile; but when body weight continued to decrease but blood glucose concentrations were increased, the cows were fertile. Level of nutrition during the critical last trimester of gestation

and after calving is associated with postpartum anestrous (Bellows and Short, 1978; Dunn and Kaltenbach, 1980; Wettemann et al., 1980). Nutrient intake during gestation may influence growth of the fetal-placenta unit, endocrine function of the placenta and ovary, and pituitary hormone synthesis and secretion after parturition. However, the mechanism by which nutrition influences reproductive performance needs to be clarified.

CHAPTER III

MATERIALS AND METHODS

Animal Management

Mature Hereford cows were used to determine whether
changes in nutrient intake during late gestation would af-
fect blood constituents and reproductive performance of
spring calving cows. The experiment was conducted on the
Lake Carl Blackwell Range in north central Oklahoma on
native range grass. Predominant forages were of the tall-
grass prairie type, mainly Andropogon, Sorghastrum and
Panicum. Dry range grass was abundant and prairie hay was
fed when ice or snow covered the grass or in late winter
when forage quality was reduced. A total of 76 mature
Herefords were blocked on four prepartum nutritional
regimes based on size, age and whether or not they weaned
a calf the previous year. Cows in each treatment were
fed in a group and nutrient intake was regulated by altera-
tion in the amount of supplemental grain and hay that was
fed. On November 10, 1981, one-fourth of the cows were
assigned to a moderate (M) level of nutrition. Cows were
fed the amount of cotton seed meal (CSM) necessary to
maintain their fall weights until parturition. The

39

remaining cows were assigned to a low (L) nutritional supplementation with the purpose that they would lose approximately 5% of their fall weight (the November 10 weight) by January 19, 1982 (approximately 60-90 days prepartum). On January 20, 1982, one-third of the L cows continued on the low plane of nutrition so that they would lose 10-15% of their fall weight by parturition (low-low; LL group). Another one-third of the L cows were fed the same amount of CSM as the M group until parturition (low-moderate; LM group). The remaining one-third of the L cows were fed 166% of the amount of supplement that the M cows received (low-high; LH group). It was anticipated that during the last 60-90 days of gestation, M cows would maintain their fall weight, LM and LH cows would gain weight and LL cows would lose weight. After calving, all cows received the moderate level of nutrition (Table 1).

Cows were weighed every two weeks after withdrawal from feed and water for 16 hours, from November 10, 1981, until calving. Body condition scores were estimated when cows were weighed and scores were assessed independently by two individuals. Body condition scores were based on a scale from 1 to 9 and a condition score of 1 was a very emaciated animal and a cow scoring 9 was extremely obese.

Blood Sampling

Blood plasma samples were collected every other week from February 4, 1982, until calving (March-May). Jugular

TABLE 1

FEEDING PROGRAM

| Data | Nutritional Treatment | | |
	Moderate	Low	High
Prepartum			
November 10, 1981			
Supplement[a] Forage	9.5 Kg	6.4 Kg Grazing Prairie Grass	--
January 20, 1982			
Supplement Forage[b]	9.5 Kg ad libitum	4.8 Kg 80 Kg/cow/week	16 Kg ad libirum
Postpartum			
Supplement Forage[c]	13 Kg	13 Kg Grazing Prairie Grass	13 Kg

[a] 41% Protein cotton seed meal pellets/week.

[b] Prairie hay fed in addition to prairie grass pastures.

[c] Ad libitum prairie hay was fed during the early period when grass was limited.

puncture was used to obtain about 40 ml of blood. Oxalic acid (32 mg) was added as an anticoagulant and the tubes of blood were immediately cooled in ice. Sodium fluoride (.1 ml/10 ml of blood of a 16 g NaF/100 ml. Oxalic acid solution) was added to inhibit metabolization of glucose by the red blood cells. Blood samples were centrifuged (5000 x g for 15 minutes), plasma was decanted and stored at -10° C. until analyzed.

Blood and Plasma Analyses

Hematocrit and total protein concentration were determined within 30 minutes after collection of blood. Blood samples were centrifuged in microhematocrit capillary tubes. Packed cell volume was determined and the remaining plasma was used to quantify plasma protein using a refractometer (American Optical, N. 10400, New York). An enzymatic colorimetric procedure (Sigma Chemical Company, N. 510, St. Louis) was utilized to determine concentrations of plasma glucose. Standard curves for each assay were developed with 0, 25, 50, 100 and 150 mg % glucose solutions to calculate concentrations in unknown samples. Use of this assay for bovine plasma in our laboratory has been described (Rasby, 1983).

Concentrations of non-esterified fatty acids in plasma were determined by the technique of Dole (1956) as modified by Patterson (1963). A standard curve was developed for each assay using 175, 350, 525 and 700 µeq/liter of

palmitic acid. The between assay coefficient of variation
for NEFA in plasma was 8.4% and the within assay coeffi-
cient of variation was 4.3. When 200 μeq of palmitic acid
was added to 0.5 ml samples of plasma from cows, 104 ± 4%
(n = 5) was recovered. Concentrations of NEFA were calcu-
lated from the standard curve and expressed as μeq/liter
of palmitate.

Hormone Quantification

Blood samples were obtained each week by tail vein
puncture between 15 and 85 days postpartum.

Concentrations of progesterone in plasma were quanti-
fied by a double antibody radioimmunoassay (Lusby et al.,
1981) and used to determine the onset of postpartum ovarian
activity. Ovarian activity was considered to have com-
menced when concentrations of progesterone in plasma were
equal to or greater than 1 ng/ml. for two consecutive weeks.

Breeding Management

Sterile bulls were used to detect estrous activity
after parturition until the beginning of the breeding sea-
son. Cows were exposed to fertile bulls equipped with
chinball markers between May 1 and August 1, 1982. Preg-
nancy rate was determined by rectal palpation in October,
1982, and dates of conception were estimated from subse-
quent calving dates.

Statistical Analysis

Least squares analyses of variance were performed using treatments as the main effect. In statistical models for treatment effects, the covariate was either age prepartum or postpartum. Other covariates were tested, but if they did not contribute significantly to variation in a particular dependent variable they were not considered.

Pooled within class correlation coefficients were obtained from the residual sum of squares and sum of products. Reproductive performance was analyzed using the analysis of variance procedure. Differences between pair means were tested with the least significant difference procedure.

CHAPTER IV

RESULTS

Body Weight

At the time of the change in nutrition (January 20), M cows had maintained their fall weight and the L cows had lost 4.4% of their weight (Table 2). From 2 to 10 weeks after nutritional change, M cows maintained their fall weights with a final prepartum weight greater (4.3%) than the fall weight. By April 1, LL and LM cows had lost 9 and 7% of their initial weights, respectively. LH cows lost only 2.5% of their fall weight and that weight was slightly greater than the weight observed at the time of the nutritional change.

Ten weeks after nutritional changes, body weights were -13.0, -11.4, -13.3 and -6.8% less than the fall weight for postpartum cows on M, LL, LM and LH treatments, respectively. However, body weight losses were greater when compared to the fall weight (-11.6, -15.8, -16.7 and -10.8% for M, LL, LM and LH treatments, respectively). Four weeks later (April 29) cows had started gaining weight (-6.7, -8.8, -11.4 and -5% of the weight at the time of nutritional change for M, LL, LM and LH treatment, respectively). The

45

TABLE 2

INFLUENCE OF NUTRITION ON BODY WEIGHT[a] (Kg)
OF RANGE BEEF COWS

Date	Weeks Before or After Change in Nutrition	Nutritional Treatment			
		Moderate	Low-Low	Low-Moderate	Low-High
Prepartum					
November 10	-10	441 ± 11	442 ± 11	431 ± 12	443 ± 11
January 20	0	448 ± 11^b	420 ± 8^c	414 ± 8^c	424 ± 10^c
February 4	2	438 ± 10^b	429 ± 10^c	400 ± 10^d	432 ± 11^{bc}
February 18	4	436 ± 11^b	412 ± 10^c	408 ± 10^c	431 ± 11^b
March 4	6	449 ± 13^b	385 ± 10^c	408 ± 10^d	424 ± 11^{bc}
March 18	8	439 ± 17^b	383 ± 15^c	393 ± 13^c	419 ± 15^{bc}
April 1	10	460 ± 20^b	402 ± 18^c	401 ± 18^d	431 ± 20^{bc}
Postpartum					
April 1	10	390 ± 10^b	372 ± 10^c	359 ± 10^c	395 ± 13^b
April 15	12	394 ± 10^b	383 ± 10^c	365 ± 10^c	397 ± 11^b
April 29	14	418 ± 10^b	383 ± 10^c	367 ± 10^{cd}	403 ± 12^{bc}

[a]Least squares means ± S.E.

[bcd]Means in a row with different superscripts differ (P<.05)

weights of postpartum cows on April 29 represent -5.2,
-13.3, -14.9 and -9.0% of the fall weight for M, LL, LM
and LH treatments respectively.

Body Condition Score

Body condition score of the cows on the four nutri-
tional treatments was also affected by treatment (Table 3).
By January 20, M cows had lost 2.9% of their initial fall
condition, while L cows had lost 17.4% (P<.05) of their
initial condition. The nutritional changes in January af-
fected body condition, and after 10 weeks, M cows had a
condition score that was greater (6.8%) than the score on
the day of the changes in nutrition. Body condition of LM
and LH cows increased from January 20, but by April 1 had
not returned to the condition score they had on November 10
(-12.1 and -9.5%, respectively). LL cows maintained the
body condition observed on January 20, but by April 29
the postpartum condition score was 22.6% less than the fall
score condition. When the body condition score was assessed
for postpartum cows (Table 3) it was observed that the
condition of these animals was reduced (-14%) when compared
to the condition of the prepartum cows on the same day
(April 1). Fourteen weeks after change in nutrition, M
cows had lost condition (-11.6%) but LL, LM and LH cows had
maintained condition from January 20.

TABLE 3

INFLUENCE OF NUTRITION ON BODY CONDITION
SCORE OF RANGE BEEF COWS

	Weeks Before or After Change in Nutrition	Nutritional Treatment			
		Moderate	Low-Low	Low-Moderate	Low-High
Prepartum					
November 10	-10	$5.95 \pm .16^b$	$6.03 \pm .18$	$5.69 \pm .15$	$6.19 \pm .26$
January 20	0	$5.78 \pm .09^c$	$4.82 \pm .18^e$	$4.78 \pm .20^e$	$5.20 \pm .16^d$
February 4	2	$5.55 \pm .12^c$	$5.06 \pm .12^e$	$4.74 \pm .12^e$	$5.30 \pm .13^{cd}$
February 18	4	$5.32 \pm .14^c$	$4.53 \pm .13^e$	$4.91 \pm .13^d$	$5.43 \pm .14^c$
March 4	6	$5.67 \pm .18^c$	$4.40 \pm .14^e$	$4.81 \pm .13^d$	$4.66 \pm .15^d$
March 18	8	$6.00 \pm .21^c$	$4.88 \pm .18^d$	$5.14 \pm .15^d$	$5.69 \pm .18^c$
April 1	10	$6.20 \pm .29^c$	$4.67 \pm .26^d$	$5.00 \pm .26^d$	$5.60 \pm .29^c$
Postpartum					
April 1	10	$4.95 \pm .15^c$	$4.32 \pm .15^d$	$4.35 \pm .16^d$	$5.17 \pm .20^c$
April 15	12	$4.92 \pm .14^c$	$4.54 \pm .13^d$	$4.38 \pm .13^d$	$5.20 \pm .15^c$
April 29	14	$5.18 \pm .13^c$	$4.75 \pm .12^d$	$4.69 \pm .12^d$	$5.25 \pm .16^c$

[a] 1 = very thin, 9 = very fat

[b] Least Squares Means

[cde] Means in a row with different superscripts differ (P<.05)

Glucose

Nutritional regimes did not significantly influence concentrations of glucose in plasma (Table 4). At 2, 4 and 6 weeks after nutritional changes, cows on the M treatment had the highest concentrations of glucose in plasma, but glucose in plasma was reduced at 8 and 10 weeks. With few exceptions, cows on LL, LM and LH treatments had stable concentrations of glucose which average 56, 53.5 and 54.5 mg %, respectively for LL, LM and LH cows from 2 to 10 weeks after the nutritional changes. Concentrations of glucose in the plasma of postpartum cows were not significantly affected by treatments (Table 4). However, M and LL cows tended to have greater concentrations of glucose from 10 to 14 weeks after the nutritional changes than cows on LM and LH treatments.

Protein

Concentrations of protein in plasma (Table 5) of cows before calving were not significantly affected by the nutritional regimes. Concentrations of protein in plasma of cows on all treatments averaged 8.12% from 2 to 10 weeks after the nutritional change. Concentrations of protein in plasma of cows after calving were not significantly affected by nutritional treatments. However, cows on the M treatment had the lowest concentration of plasma protein (8.0%) compared to the values observed in LL, LM and LH

TABLE 4

INFLUENCE OF NUTRITION ON BLOOD GLUCOSE[a] (mg/%)
IN RANGE BEEF COWS

	Weeks After Change in Nutrition	Nutritional Treatment			
		Moderate	Low-Low	Low-Moderate	Low-High
Prepartum					
February 4	2	57.2 ± 1.6	52.9 ± 1.6	53.5 ± 1.6	54.9 ± 1.8
February 18	4	57.9 ± 2.3	56.8 ± 2.1	53.7 ± 2.1	54.6 ± 2.3
March 4	6	58.0 ± 2.9	56.2 ± 2.3	53.7 ± 2.1	54.1 ± 2.4
March 18	8	52.8 ± 3.3	55.8 ± 2.9	53.0 ± 2.4	54.3 ± 2.9
April 1	10	53.0 ± 3.9	56.0 ± 3.5	49.2 ± 3.5	55.0 ± 3.9
Postpartum					
April 1	10	58.9 ± 2.5	57.2 ± 2.5	55.6 ± 2.6	54.7 ± 3.3
April 15	12	56.2 ± 2.4	57.2 ± 2.3	54.2 ± 2.2	52.2 ± 2.6
April 29	14	57.1 ± 2.2	56.6 ± 2.1	55.1 ± 2.1	54.9 ± 2.1

[a] Lease Squares Means ± S.E.

TABLE 5

INFLUENCE OF NUTRITION ON PLASMA PROTEIN[a](%)
IN RANGE BEEF COWS

	Weeks After Change in Nutrition	Nutritional Treatment			
		Moderate	Low-Low	Low-Moderate	Low-High
Prepartum					
February 4	2	7.89 ± .10	7.93 ± .11	8.12 ± .11	8.00 ± .12
February 18	4	8.04 ± .11	8.30 ± .10	8.34 ± .10	8.14 ± .11
March 4	6	8.10 ± .16	8.26 ± .13	8.29 ± .12	8.15 ± .13
March 18	8	7.95 ± .18	8.26 ± .16	8.20 ± .14	7.99 ± .16
April 1	10	7.94 ± .24	8.33 ± .22	8.18 ± .22	8.00 ± .24
Postpartum					
April 1	10	8.05 ± .12	8.28 ± .12	8.37 ± .13	8.40 ± .16
April 15	12	8.03 ± .12	8.34 ± .12	8.23 ± .11	8.30 ± .13
April 29	14	8.03 ± .12	8.29 ± .11	8.30 ± .11	8.29 ± .14

[a]Lease Squares Means ± S.E.

groups of cows.

Non-Esterified Fatty Acids

Concentrations of NEFA in plasma of pregnant cows were not significantly influenced by nutritional regimes (Table 6). Least square means of cows on the M treatment were reduced (948 µeq/l) at the same period and cows on the LM treatment had intermediate concentrations (1097 µeq/l). Plasma concentrations of NEFA in postpartum cows were not significantly influenced by treatments. Cows on the M and LM treatments had similar average concentrations (1020 µeq/l) which were comparable to concentrations observed from 2 to 6 weeks after nutritional changes. Cows on LL and LH treatments had the greatest concentrations of NEFA (1107 and 1228 µeq/l, respectively).

Hematocrit

Hematocrit values are summarized in Table 7. Cows on the LH treatment had greater (P<.05) hematocrits than the other groups at 2 weeks and greater (P<.05) hematocrits than M and LL cows at 4 to 6 weeks after the nutritional changes. By 10 weeks after the nutritional changes hematocrits were similar for prepartum cows on all treatments. Hematocrit values after calving were reduced in the cows on M and LL treatments when compared to prepartum cows on similar treatments. However, hematocrits for prepartum and postpartum cows on LM and LH treatments were similar.

TABLE 6

INFLUENCE OF NUTRITION ON PLASMA NEFA^a(μeq/l)
IN RANGE BEEF COWS

	Weeks After Change in Nutrition	Nutritional Treatment			
		Moderate	Low-Low	Low-Moderate	Low-High
Prepartum					
February 4	2	975 ± 91	1232 ± 94	1093 ± 94	1211 ± 104
February 18	4	992 ± 101	1128 ± 91	1062 ± 91	1193 ± 101
March 4	6	961 ± 131	1198 ± 105	1049 ± 98	1218 ± 109
March 18	8	865 ± 144	1232 ± 125	1152 ± 106	1135 ± 125
April 1	10	947 ± 172	1221 ± 157	1127 ± 157	1241 ± 172
Postpartum					
April 1	10	1020 ± 116	1077 ± 116	1048 ± 122	1289 ± 157
April 15	12	998 ± 106	1142 ± 102	1034 ± 98	1192 ± 116
April 29	14	1040 ± 95	1102 ± 89	1004 ± 89	1203 ± 113

^{a}Least squares Means ± S.E.

TABLE 7

INFLUENCE OF NUTRITION ON HEMATOCRIT[a] (%)
IN RANGE BEEF COWS

	Weeks After Change in Nutrition	Nutritional Treatment			
		Moderate	Low-Low	Low-Moderate	Low-High
Prepartum					
February 4	2	33.8 ± 0.8^c	31.4 ± 0.8^d	34.4 ± 0.8^c	37.2 ± 0.8^b
February 18	4	36.4 ± 1.1^c	36.9 ± 1.0^c	38.1 ± 1.0^{bc}	39.9 ± 1.1^b
March 4	6	36.6 ± 1.4^c	37.1 ± 1.1^c	38.1 ± 1.0^{bc}	40.4 ± 1.2^b
March 18	8	37.8 ± 1.9	37.6 ± 1.6	38.0 ± 1.4	41.3 ± 1.6
April 1	10	38.2 ± 2.1	39.3 ± 1.9	37.2 ± 1.9	39.6 ± 2.1
Postpartum					
April 1	10	35.4 ± 1.1^c	35.5 ± 1.1^c	39.3 ± 1.2^b	40.3 ± 1.5^b
April 15	12	35.8 ± 1.1^c	35.8 ± 1.1^c	38.9 ± 1.0^b	40.9 ± 1.2^b
April 29	14	36.4 ± 1.1^c	36.7 ± 1.0^c	38.4 ± 1.0^{bc}	40.0 ± 1.3^b

[a]Lease Squares Means ± S.E.

[bc]Means in a row with different superscripts differ (P<.05)

Hematocrits were greater (P<.05) for LH and LM postpartum cows than for M and LL cows from 10 to 12 weeks after nutritional changes.

Correlations

Pooled within class correlation coefficients (adjusted for treatments) for different periods prepartum are presented in Tables 8, 9 and 10. Body condition of the cows was significantly correlated with hematocrit, NEFA and body weight from 2 to 6 weeks after the nutritional changes. Changes in body weight were correlated (P<.001) with changes in body condition score. Body weight was correlated (P<.05) with NEFA in plasma of prepartum cows at 2 and 6 weeks after the nutritional change. Plasma protein was correlated with concentration of glucose (P<.01) and body weight at 4 and 6 weeks after the nutritional change and nonsignificant positive correlations were observed at 2 weeks after nutritional change. Similarly, concentrations of protein in plasma during the postpartum period were significant correlated with concentrations of glucose and body weight (Tables 11, 12 and 13).

Changes in body weight from November until various times postpartum were significant and negatively correlated with plasma concentration of NEFA and positively correlated with body weight and body condition score. Changes in body condition were significant and negatively correlated with concentrations of NEFA in plasma and positively correlated

TABLE 8

POOLED WITHIN CLASS CORRELATION COEFFICIENTS[a] FOR BLOOD
AND BODY PARAMETERS OF PREPARTUM BEEF COWS
TWO WEEKS AFTER THE NUTRITIONAL CHANGES

N=61	PROT	HCT	NEFA	BW	BCS	BWC	BCSC
GLU	.14	-.12	-.01	-.05	-.14	-.21	-.13
PROT	--	.14	.06	.20	.17	.06	-.01
HCT	--	--	-.07	.13	.42**	.08	.05
NEFA	--	--	--	.29*	.23*	-.14	-.09
BW	--	--	--	--	.47**	-.04	-.08
BCS	--	--	--	--	--	.002	.21
BWC	--	--	--	--	--	--	.65**

[a]Glucose (GLU), protein (PROT), hematocrit (HCT), non-
esterified fatty acids (NEFA), body weight (BW), body
condition score (BCS), changes in body weight (BWC) and
body condition score (BCSC)

* (P<.05)

** (P<.01)

TABLE 9

POOLED WITHIN CLASS CORRELATION COEFFICIENTS[a] FOR BLOOD
AND BODY PARAMETERS OF PREPARTUM BEEF COWS
FOUR WEEKS AFTER THE NUTRITIONAL CHANGES

N=57	PROT	HCT	NEFA	BW	BCS	BWC	BCSC
GLU	.36**	−.15	−.02	.11	−.05	−.01	−.12
PROT	--	.09	.21	.37**	.15	−.08	−.07
HCT	--	--	.02	.03	.30*	−.11	0.06
NEFA	--	--	--	.19	.41**	−.30*	.04
BW	--	--	--	--	.37**	−.06	−.07
NCS	--	--	--	--	--	−.24*	.21
BWC	--	--	--	--	--	--	.61**

[a]Glucose (GLU), protein (PROT), hematocrit (HCT), non-
esterified fatty acids (NEFA), body weight (BW), body
tion score (BCS), changes in body weight (BWC) and body
condition score (BCSC)

 * (P<.05)

** (P<.01)

TABLE 10

POOLED WITHIN CLASS CORRELATION COEFFICIENTS[a] FOR BLOOD
AND BODY PARAMETERS OF PREPARTUM BEEF COWS
SIX WEEKS AFTER THE NUTRITIONAL CHANGES

N=47	PROT	NCT	NEFA	BW	BCS	BWC	BCSC
GLU	.40**	-.12	.04	.04	-.03	-.06	-.06
PROT	--	.07	.23	.34*	.22	-.06	.01
HCT	--	--	-.08	.11	.45**	-.15	.09
NEFA	--	--	--	.35*	.27*	-.21	-.13
BW	--	--	--	--	.35*	-.13	-.12
BCS	--	--	--	--	--	-.05	.43**
BWC	--	--	--	--	--	--	.65**

[a]Glucose (GLY), protein (PROT), hematocrit (HCT), non-
esterified fatty acids (NEFA), body weight (BW), body
condition score (BCS), changes in body weight (BWC) and
body condition score (BCSC)

  * (P<.05)

** (P<.01)

TABLE 11

POOLED WITHIN CLASS CORRELATION COEFFICIENTS[a] FOR BLOOD
AND BODY PARAMETERS OF POSTPARTUM BEEF COWS
TEN WEEKS AFTER THE NUTRITIONAL CHANGES

N=33	PROT	HCT	NEFA	BW	BCS	BWC	BCSC
GLU	.44**	.09	.20	.13	.30*	-.02	.04
PROT	--	.07	.25	.34*	-.09	-.05	-.10
HCT	--	--	-.08	-.08	-.97	-.16	-.27
NEFA	--	--	--	-.13	-.17	-.40*	-.35*
BW	--	--	--	--	.21	.46**	.20
BCS	--	--	--	--	--	.15	.58**
BWC	--	--	--	--	--	--	.67**

[a]Glucose (GLU), protein (PROT), hematocrit (HCT), non-
esterified fatty acids (NEFA), body weight (BW), body
condition score (BCS), changes in body weight (BWC) and
body condition score (BCSC)

*(P<.05)

**(P<.01)

TABLE 13

POOLED WITHIN CLASS CORRELATION COEFFICIENTS[a] FOR BLOOD
AND BODY PARAMETERS OF POSTPARTUM BEEF COWS
FOURTEEN WEEKS AFTER THE
NUTRITIONAL CHANGES

N=51	PROT	HCT	NEFA	BW	BCS	BWC	BCSC
GLU	.32*	−.07	.09	.03	.001	−.09	−.02
PROT	--	.06	.20	.26*	.11	−.07	−.03
HCT	--	--	.02	.13	.37**	.09	.05
HEFA	--	--	--	−.001	−.14	−.32*	−.35*
BW	--	--	--	--	.52**	.32*	.25*
BCS	--	--	--	--	--	.26	.49**
BWC	--	--	--	--	--	--	.70**

[a]Glucose (GLU), protein (PROT), hematocrit (HCT), non-
esterified fatty acids (NEFA), body weight (BW), body
condition score (BCS), changes in body weight (BWC) and
body condition score (BCSC)

* (P<.05)

** (P<.01)

TABLE 12

POOLED WITHIN CLASS CORRELATION COEFFICIENTS[a] FOR BLOOD
AND BODY PARAMETERS OF POSTPARTUM BEEF COWS
TWELVE WEEKS AFTER THE NUTRITIONAL CHANGES

N=44	PROT	NCT	NEFA	BW	BCS	BWC	BCSC
GLU	.34*	-.07	.12	.15	.07	-.08	-.10
PROT	--	.03	.25	.34*	.02	-.03	-.07
HCT	--	--	-.05	-.11	.22	-.12	-.07
NEFA	--	--	--	-.12	-.37*	-.34*	-.42**
BW	--	--	--	--	.32*	.34*	.24
BCS	--	--	--	--	--	.31*	.60**
BWC	--	--	--	--	--	--	.37**

[a]Glucose (GLU), protein (PROT), hematocrit (HCT), non-
esterified fatty acids (NEFA), body weight (BW), body
condition score (BCS), changes in body weight (BWC) and
body condition score (BCSC)

* (P<.05)

** (P<.01)

(P<.01) to body condition and changes in body weight during the postpartum period. Except for 10 weeks after the nutritional change, body weight was significantly cor-related with body condition score.

Reproductive Performance

Reproductive performance of the cows is summarized in Table 14. For all the criteria studied, cows on the moderate nutritional treatment performed better than cows that were fed the low nutritional regimes at some time during the prepartum period. The most dramatic differences (P<.01) were observed in the percentage of cows with ovarian activity by 85 days after calving (68.4 vs. 17.7, 33.3 and 23.1% for M vs. LL, LM and LH, respectively); percentage of cows in estrus by 85 days postpartum (53 and 46.2% vs 0 and 16.7% for M and LH vs. LL and LM cows, respectively) and pregnancy rate (84.2, 17.7, 41.2 and 62.0% for M, LL, LM and LH respectively).

Moderate and high nutritional regimes for cows with restricted intake before the time of the nutritional changes affected neither and onset of ovarian activity nor the interval from calving to conception for those cows that conceived.

Birth weight of calves (Table 15) from cows on the M treatment were heavier (P<.10) than those from LL cows. Weights of calves from cows on LM and LH treatments were not different from the calves from cows on the other treatments.

TABLE 14

INFLUENCE OF NUTRITION DURING LATE GESTATION ON REPRODUCTIVE
PERFORMANCE IN RANGE BEEF COWS

Criteria	Nutritional Treatment			
	Moderate	Low-Low	Low-Moderate	Low-High
No. of cows	19	18	17	13
Onset ovarian activity by 85 days[e] (%)	68.4^a	17.7^b	33.3^b	23.1^b
Onset ovarian activity[fg] (days)	56 ± 5^a	72 ± 6^{ab}	73 ± 4^{ab}	82 ± 1^b
Estrus by 85 days (%)	53.0^a	0	16.7^b	46.2^a
Pregnancy at the end breeding season[h] (%)	84.2^a	17.7^d	41.2^c	62.0^b
First estrus for cows cycling during breeding season[i] (days)	46 ± 5 (10)	0	48 ± 22 (3)	69 ± 8 (6)
Parturition to conception (days)	84 ± 7 (16)	91 ± 10 (4)	86 ± 12 (6)	89 ± 4 (8)

[abcd]Means in a row with different superscripts differ (P<.01)

[e]Cows with ovarian activity by 85 days

[f]Means ± S.E.

[g]Characterized by concentration of progesterone in plasma equal or greater than 1 ng/ml for two consecutive weeks

[h]Determined by rectal palpation 75 days after the end of the breding season

[i]Number in parenthesis equals number of cows if less than total number of cows in each group

TABLE 15

BIRTH WEIGHT OF CALVES^c(Kg) FROM COWS ON
DIFFERENT NUTRITIONAL REGIMES

Treatment		Birth Weight
Moderate	n=14	35.5 ± 1.6^a
Low-Low	n=15	30.9 ± 0.9^b
Low-Moderate	n=16	34.5 ± 1.1^{ab}
Low-High	n=13	34.3 ± 1.8^{ab}

^{ab}Means in a column with different super-
scripts differ (P<.10)

^{c}Means ± S.E.

CHAPTER V

DISCUSSION

Body weight was maintained until parturition in cows
fed a moderate amount of supplement. By January 20, cows
on restricted supplementation lost 4.4% of the fall weight
and ten weeks later (near the time of parturition) body
weight changes were -9.0, -7.0 and -2.7% of the fall weight
for LL, LM and LH cows, respectively. At calving, moderate
cows had the greatest weight loss, 70 Kg compared to 30, 42
and 36 Kg for LL, LM and LH cows, respectively. Body
weight of calves at birth (P<.10) were 35.5, 30.9, 34.5
and 34.3 Kg for M, LL, LM and LH nutritional treatments,
respectively. In previous trial, Rasby (1983) found no
differences in the weight of the calves at birth. However,
percentage of body weight changes and condition of the cows
at calving under similar treatments were not different.
Changes in body condition during gestation were similar to
the changes in body weight. By January 20, cows in the
restricted diet had lost 17.4% of their fall condition and
moderate cows, even though they gained weight, had a 2.9%
decrease in body condition score. At parturition, M cows
were in better body condition than cows that were fed the
low amount of supplementation at any time during the

65

prepartum period. Before and after calving body weight and body condition score were significantly correlated. Changes in body weight and body condition score from values at the beginning of the experiment (November) were also correlated. This indicates that the body condition score is useful to estimate energy reserves in cows and it is not necessary to weigh cows to determine weight losses. Changes in body weight during gestation are confounded by changes in calf weight (Bowden et al., 1979), and use of body condition score may eliminate this problem.

Body weight and body condition changes, induced by nutritional treatments affected reproductive performance. Percentage of cows with ovarian activity (progesterone in plasma equal or greater than 1 ng/ml for two consecutive weeks) by 85 days after calving was greatest (68.4%) in the cows that maintained weight and condition (M cows) compared to cows that lost weight and condition during the prepartum period (17.7, 33.3 and 23.1% for cows on LL, LM and LH treatments, respectively). Similarly, the time to the onset of ovarian activity was influenced by nutritional treatment. Weight changes around parturition affect the onset of first estrus at 40-50 days after calving (Whitman et al., 1975). Dunn (1980) reported that negative pre-partum weight changes prolonged the interval to first estrus. Similarly, when cows were in good body condition at calving, more were in estrus by 60 days postpartum regardless of weight changes around parturition (Dunn and

Kaltenbach, 1980). Moderate amounts of supplement after parturition did not influence the onset of ovarian activity if the cows were fed low amounts of supplement during pregnancy. A similar response was observed when the diets of pregnant cows were increased to moderate or high amounts 60 days before the expected date of calving (Dunn, 1980).

Mobley (1982) found a greater concentration of progesterone from day-30 to day-10 prepartum in cows maintaining weight during the prepartum period compared to cows losing weight. Concentrations of estrogen in plasma during gestation were also influenced by nutrient intake. This suggests that nutrient inadequacy during the prepartum period may influence endocrine secretions during the prepartum period.

Increased amounts of supplement in the last 2 months of pregnancy for cows receiving restricted feeding during mid pregnancy (LM and LH) resulted in significant increases in estrus and pregnancy rates during the breeding season compared to cows maintained on the low treatment. Similar observations were made by Bellows and Short (1978), Donaldson et al. (1967) and Wiltbank et al. (1962). Reduced supplementation during the prepartum period was followed by reduced percentages of estrus and conception during the breeding season. Wiltbank et al. (1962) observed that when cows received extra energy after calving, it did not overcome the effect of reduced energy intake prior to calving on reproductive performance. The interval from parturition

to conception was not affected when different nutritional treatments were used during the prepartum period. Wettemann et al. (1984) found that feeding cows a high energy diet for 4 weeks near the beginning of the breeding season did not improve reproductive performance of suckled cows.

Plasma concentrations of glucose and non-esterified fatty acids were not significantly affected by treatments either during the prepartum or postpartum periods. Moderate cows had the lowest concentrations of NEFA in plasma and greatest concentration of glucose in plasma. This response may indicate a favorable energetic balance. Cows on the restricted intake before calving had the greatest concentrations of NEFA in plasma, indicating active fat mobilization during the period of high energy requirement. Significant negative correlations between concentrations of NEFA in plasma after calving and changes in weight and condition may reflect the high energy demands during the postpartum period, especially due to lactation. Wagner and Oxenreider (1971) found decreased glucose concentration in plasma when cows were fed a restricted energy intake during the post-partum period. A relationship between plasma glucose concentration and fertility has been suggested (McClure, 1980; Horrocks and Paterson, 1960; Howland et al., 1966; Oxen-reider and Wagner, 1971). Cows on moderate supplementation during the prepartum period had higher glucose concentration compared to cows fed low, moderate or high nutritional regimes (Rasby, 1983). However, pregnancy rate was not

affected (91.7, 76.5, 94.7 and 89.5% for cows on M, LL, LM and LH treatments, respectively). Although diet influenced plasma concentrations of glucose, body condition was not altered significantly by diet to have dramatic effects on reproductive performance.

Plasma protein concentrations were not affected by the different nutritional treatments before calving. Cows fed moderate and high nutritional regimes had the lowest concentrations of proteins. After calving, cows on the M treatments had the lowest plasma concentration of protein. Total protein concentrations in plasma in dairy cows were not altered by feeding either high or low protein diets before and after calving (Trecher et al., 1976). We found significant correlations between concentrations of protein in plasma and body weight of the cows before and after parturition, possibly indicating that plasma protein could be an indicator of condition of the animal.

Treacher et al. (1976) observed that different amounts of supplement did not affect packed cell volume in dairy cows. However, our beef cows fed either moderate or high supplementation after a restricted intake had increased hematocrit values after calving when compared to cows fed moderate or low supplementation. During the prepartum period, hematocrits were significantly correlated to the condition score of the animals, suggesting that hematocrit may be an indicator of condition of the animal. Hematocrit was significantly correlated to condition of the postpartum

cows at 14 weeks after change of the nutritional treatments.

In conclusion, this study indicates that moderate and high nutritional regimes in the last 60 days of pregnancy did not overcome the effect of a restricted intake during mid pregnancy on reproductive performance. Although plasma constituents were not affected by nutritional treatments, protein and NEFA concentrations in plasma were correlated to body weight and condition of the animals before and after calving. Losses of weight and condition during the prepartum period significantly affected the onset of ovarian activity by 85 days postpartum and percentage of pregnancy at the end of the breeding season. This may suggest that animals with negative energetic balance during pregnancy had reduced endocrine function during the postpartum period.

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