



Reproductive efficiency of range beef cows fed differing sources of protein during gestation and differing quantities of ruminally undegradable protein prior to breeding
by Daniel Vincent Dhuyvetter

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in
Animal Science
Montana State University
© Copyright by Daniel Vincent Dhuyvetter (1991)

Abstract:

Three experiments utilizing 165 crossbred multiparous beef cows grazing native spring range were conducted to determine the effects of pre- and postpartum protein supplementation on nutrient status, milk production, and subsequent calf and reproductive performance. In experiment one, two and three, pregnant cows were fed 20% crude protein supplements formulated with alfalfa or canola every other day at 1.82 kg/hd from 12-5-91 until calving. In the third experiment using three-year-old cows, a third treatment was added, which was designed to serve as an energy control consisting only of 1.6 kg beet pulp/hd fed on alternate days. After parturition cows in all three experiments were fed one of two iso-nitrogenous and iso-energetic supplements. One experimental supplement designated ruminally undegraded (UD) was formulated to contain .245 kg of ruminally degradable and .245 kg of ruminally undegradable protein daily. The second supplement designated ruminally degraded (RD) was formulated to supply .371 kg ruminally degradable protein and .119 kg undegradable protein daily. These supplements were fed on alternate days at 1.82 kg/hd until the breeding season. Experiment 1 consisted of late calving cows that grazed spring range and were individually fed supplement postpartum. Experiment 2, composed of early calving cows, and experiment 3, consisting of three year old cows moved from the Montana State University Livestock Center after calving, were group fed supplement on alternate days and daily fed one-half ration of medium quality hay (10.5% CP). In Exp. 1 BUN concentration was 1.8 mg/dl higher ($P < .01$) on day 53 postpartum for UD fed cows. Milk production did not differ due to prepartum or postpartum treatments. Prepartum weight gain was greater for canola-fed cows ($P < .001$) compared to alfalfa. Group-fed cows experienced less postpartum weight loss prior to the breeding season when fed UD supplement ($P < .001$). Preweaning calf gain, cow fecal output and fall pregnancy rates were unaffected by pre- and postcalving supplementation. Three year old cows fed beet pulp prepartum were less ($P < .001$) frequently serviced in the first 21 days of the breeding season (54.5%) than the canola- or alfalfa-fed cows (95% and 96% respectively). Overall, pre- and postpartum protein supplementation affected cow weight change and allowed for high reproductive performance between cows fed either RD or UD protein supplement postpartum.

REPRODUCTIVE EFFICIENCY OF RANGE BEEF COWS FED DIFFERING
SOURCES OF PROTEIN DURING GESTATION AND DIFFERING
QUANTITIES OF RUMINALLY UNDEGRADABLE
PROTEIN PRIOR TO BREEDING

by

Daniel Vincent Dhuyvetter

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Animal Science

MONTANA STATE UNIVERSITY
Bozeman, Montana

November 1991

U378
D5395

ii

APPROVAL

of a thesis submitted by

Dan Dhuyvetter

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

12/2/91
Date

Ray Anstegen
Chairperson, Graduate Committee

Approved for the Major Department

12/2/91
Date

L. C. Gagnon
Head, Major Department

Approved for the College of Graduate Studies

12/17/91
Date

Henry L. Parsons
Graduate Dean

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a masters degree at Montana State University, I agree that the Library shall make it available to borrowers under rules of the Library. Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made.

Permission for extensive quotation from or reproduction of this thesis may be granted by my major professor, or in his absence, by the Dean of Libraries when, in the opinion of either, the proposed use of the material is for scholarly purposes. Any copying or use of the material in this thesis for financial gain shall not be allowed without my written permission.

Signature *David R. Thompson*
Date 11-29-91

ACKNOWLEDGEMENTS

I would first like to extend my sincere appreciation to my initial major advisor, Dr. Mark Petersen. Committee members Drs. Mike Tess, Bob Bellows and Roger Brownson were very helpful in keeping me aware of the "whole picture" when reviewing research results. A special thanks is also extended to Dr. Ray Ansotegui for his assistance on the ranch, not to mention his knowledge of biochemistry. The Montana Beef Council deserves recognition for providing the funding for this project. I thank the North Dakota State University Ext. Service, who helped financially as well as providing me the reason for obtaining a masters degree. Bruce Nicely and Zan Brady were very helpful in data collection and should be recognized. Pete Oland, Russell Maack and Ken Bryan provided much assistance between the study sites. The gang at the "Nut Center", you truly take the pain out of lab work and I could not have finished without your help. A special thanks to all the secretaries in the Department for their help. Laura Babcock spent many hours assisting me with the not so glamorous lab work and data collections. Your help, companionship and cheerful attitude always kept me looking on the bright-side.

Last but not least, I would like to thank my fellow graduate students. You are a great bunch, and I will always remember the cohesiveness that we shared and the help that you unselfishly gave. Good Luck in your future endeavors.

TABLE OF CONTENTS

	Page
LIST OF TABLES.....	vi
LIST OF FIGURES.....	viii
ABSTRACT.....	ix
1. INTRODUCTION.....	1
2. LITERATURE REVIEW.....	5
3. MATERIALS AND METHODS.....	17
Statistical Analysis.....	27
4. RESULTS AND DISCUSSION.....	29
Prepartum weight and condition score change....	29
Postpartum weight and condition score change...	29
Fecal output (late calving cows).....	35
Milk production (late calving cows).....	36
Preweaning calf gains.....	37
Blood metabolites (late calving cows).....	39
Insulin concentrations (late calving cows).....	41
Days to estrus (late calving cows).....	42
Percent cycling prior to breeding season.....	44
Percent serviced in 21 days.....	45
Pregnancy Rate.....	46
Reproductive efficiency.....	48
5. CONCLUSION.....	50
LITERATURE CITED.....	52
APPENDIX.....	63

LIST OF TABLES

Table	Page
1. Formulation of protein supplements for ruminally degradable (RU) and undegradable (UD)....	20
2. Lab analysis of rumen extrusa samples collected on day 36 and 64.....	21
3. Rumen degradable (RD) and rumen undegradable (UD) protein supplement chemical analysis.....	23
4. The effect of prepartum protein supplementation on beef cow weight (wt) and condition score (cs) prior to parturition.....	32
5. The effect of postpartum protein supplementation on beef cow weight (wt) and condition score (cs) post calving.....	33
6. Average fecal output of individually fed cows receiving either RD or UD supplement postpartum.....	35
7. The effect of pre- and postpartum protein supplementation on blood metabolites of beef cows post calving.....	40
8. The effect of pre- and postpartum supplements on insulin concentrations (ng/dl), of late calving cows in experiment one.....	42
9. The effect of pre- and postpartum protein supplementation on percent cycling prior to the breeding season (cycl), days to first estrus (dte), percent serviced in the first 21 days of the breeding season (21d) and percent pregnant (preg).....	47
10. Repeated measures analysis of variance for blood urea nitrogen (BUN), serum cholesterol, and serum albumin concentration.....	64
11. Repeated measures analysis of variance for serum glucose and insulin concentrations.....	65
12. Repeated measures analysis of variance for milk production.....	66
13. Analysis of variance for preweaning calf gain in experiment one, experiment two and experiment three	67

LIST OF TABLES

Table	Page
14. Analysis of variance for prepartum (December and March), cow condition scores (cs) and condition score change in experiment one, experiment two and experiment three.....	68
15. Analysis of variance for postpartum (May and August), cow condition scores (cs) in experiment one, experiment two and experiment three.....	69
16. Analysis of variance for postpartum cow condition score (cs) changes (March-May) and (May-August) in experiment one, experiment two and experiment three.....	70
17. Analysis of variance for prepartum (December and March), cow weights and weight change in experiment one, experiment two and experiment three.....	71
18. Analysis of variance for postpartum (May and August), cow weight in experiment one, experiment two and experiment three.....	72
19. Analysis of variance for postpartum cow weight changes (March-May) and (May-August) in experiment one, experiment two and experiment three.	73
20. Observed values used in chi-square analysis of percent cycling prior to the breeding season, serviced in first 21 days of breeding season and percent pregnant in experiment two.....	74
21. Observed values used in chi-square analysis of percent cycling prior to the breeding season, serviced in first 21 days of breeding season and percent pregnant in experiment three....	75
22. Observed values used in chi-square analysis of percent serviced in first 21 days of breeding season and percent pregnant in experiment one.....	76
23. Analysis of variance for days to first estrus in experiment one.....	77
24. The effect of prepartum protein supplementation on beef cow weight (wt) and condition score (cs) postpartum.....	78

LIST OF FIGURES

Figure	Page
1. In situ dry matter disappearance rate describing ruminally degradable and ruminally undegradable protein supplements over 48 hours...	19
2. In situ protein disappearance rate describing ruminally degradable and ruminally undegradable protein supplements over 48 hours...	20
3. Experimental design and chronological order of the study.....	26
4. Milk production estimated on day 39 and 53 in Exp. 1.....	37
5. Preweaning calf gain for Exp. 1, 2 and 3.....	39

ABSTRACT

Three experiments utilizing 165 crossbred multiparous beef cows grazing native spring range were conducted to determine the effects of pre- and postpartum protein supplementation on nutrient status, milk production, and subsequent calf and reproductive performance. In experiment one, two and three, pregnant cows were fed 20% crude protein supplements formulated with alfalfa or canola every other day at 1.82 kg/hd from 12-5-91 until calving. In the third experiment using three-year-old cows, a third treatment was added, which was designed to serve as an energy control consisting only of 1.6 kg beet pulp/hd fed on alternate days. After parturition cows in all three experiments were fed one of two iso-nitrogenous and iso-energetic supplements. One experimental supplement designated ruminally undegraded (UD) was formulated to contain .245 kg of ruminally degradable and .245 kg of ruminally undegradable protein daily. The second supplement designated ruminally degraded (RD) was formulated to supply .371 kg ruminally degradable protein and .119 kg undegradable protein daily. These supplements were fed on alternate days at 1.82 kg/hd until the breeding season. Experiment 1 consisted of late calving cows that grazed spring range and were individually fed supplement postpartum. Experiment 2, composed of early calving cows, and experiment 3, consisting of three year old cows moved from the Montana State University Livestock Center after calving, were group fed supplement on alternate days and daily fed one-half ration of medium quality hay (10.5% CP). In Exp. 1 BUN concentration was 1.8 mg/dl higher ($P < .01$) on day 53 postpartum for UD fed cows. Milk production did not differ due to prepartum or postpartum treatments. Prepartum weight gain was greater for canola-fed cows ($P < .001$) compared to alfalfa. Group-fed cows experienced less postpartum weight loss prior to the breeding season when fed UD supplement ($P < .001$). Preweaning calf gain, cow fecal output and fall pregnancy rates were unaffected by pre- and postcalving supplementation. Three year old cows fed beet pulp prepartum were less ($P < .001$) frequently serviced in the first 21 days of the breeding season (54.5%) than the canola- or alfalfa-fed cows (95% and 96% respectively). Overall, pre- and postpartum protein supplementation affected cow weight change and allowed for high reproductive performance between cows fed either RD or UD protein supplement postpartum.

CHAPTER 1

INTRODUCTION

Two areas which can increase commercial beef cow-calf producer profitability are:

- 1) reduction in feed costs for cow maintenance.
- 2) increase reproductive efficiency.

(Dickerson, 1969)

The first area of economic consideration is self-explanatory, while the second can simply be defined as total number of calves weaned per cow exposed to a bull. The most important factor reducing net calf crop is the failure of cows to become pregnant (Dzuik and Bellows, 1983). This can be taken one step further and used to explain the impact of postpartum interval. As the length of the postpartum interval increases, total pounds of calf weaned will decrease in the subsequent year due to younger calves or fewer calves resulting from a defined breeding season.

Inadequate precalving and/or postcalving energy or protein nutrition lowers pregnancy rates as well as first-service conception rates and extends the postpartum interval in suckled beef females (Randel, 1990). Dietary restrictions during the late prepartum period results in weight loss and decreased maternal tissue at calving, which lowers the number of cows that return to estrus early in a defined breeding season (Whitman, 1975; Wettemann et al., 1982; Dziuk and Bellows, 1983). Similar observations have been reported when

postpartum dietary restrictions have occurred (Rutter and Randel, 1984; Rakestraw et al., 1986; Richards et al., 1986).

Energy intake of the brood cow has been studied in greater detail than other nutrients. There are disagreements as to the most strategic period for increased energy intake in order to maintain reproductive efficiency.

The mechanism regulating rebreeding performance in the beef cow is unclear at this time. Dziuk and Bellows (1983) and Richards et al. (1986) have suggested a minimum body condition score of greater than or equal to 5 (range of 1 to 9) at calving for acceptable reproduction. This minimum guideline was recommended to insure that body stores of nutrients are adequate for demands of postpartum reproductive performance and lactation. This recommendation may be expensive if in fact there are mechanisms which regulate reproduction that do not require this storage of nutrients.

Rutter and Randel (1984) found that loss of body condition, not necessarily body weight, after calving greatly increases the time to first estrus. The conclusions of Sasser et al. (1988) were similar to those of Rutter and Randel (1984). However, Sasser manipulated postpartum nutrient intake by decreasing protein consumption in contrast to Rutter and Randel (1984). Sasser et al. reported that first service conception and overall pregnancy rates were lower for the protein restricted heifers.

Types of protein (Halfpop et al., 1988; Hunter and Magner

1988) have also been shown to influence reproductive responses. The site of digestion of the protein supplement seems to have an affect on the length of time to first estrus and pregnancy rate early in the breeding season. In another study (Wiley et al. 1991) prepartum heifers fed a restricted nutrient intake compensated in body weight after calving by having a more rapid weight gain than heifers fed ad libitum. While heifers that were fed to maintain body weight prepartum showed estrus sooner than those loosing weight, there was no difference in fall pregnancy rate. Cows receiving a ruminally undegradable protein supplement postpartum had fewer days to first estrus and a higher breeding rate early in the breeding season (Wiley 1991) regardless of their prepartum nutrition (restricted or ad libitum).

Since undegradable protein has been shown to influence postpartum reproduction regardless of prepartum energy levels, beef cows grazing winter and spring range would be an ideal model to test this supplemental regime because of the variability in the nutrient supply that range provides as well as the difficulty in providing energy supplements to cows grazing range. Furthermore, by formulating the supplements to be iso-nitrogenous, quantity vs. site of protein utilization could be investigated.

If manipulation of protein intake after parturition shortened the postpartum interval then more cows would become pregnant early in the breeding season. This should result in

an increase in total pounds of calf weaned per cow exposed and possibly a reduction in cows culled due to infertility.

With the above mentioned goals in mind, the objectives of these experiments were: 1) determine the effect of ruminally undegraded protein fed postpartum on reproductive performance of lactating beef cows grazing spring range, (ie. days to first estrus, first service pregnancy rate, overall pregnancy rate); 2) determine milk production, cow and calf weight changes, and cow body condition scores as influenced by cow intake of postpartum ruminally undegradable protein.

CHAPTER 2

LITERATURE REVIEW

Postpartum infertility in beef cattle can be attributed to four factors: general infertility, lack of uterine involution, short estrous cycles and anestrus (Short et al. 1990). Anestrus is the major component of postpartum infertility which is largely affected by suckling and nutrition. These factors can have a direct influence as well as interact with one another to control postpartum anestrus or postpartum interval.

Nutrition, specifically the energy component, has received the most research emphasis in the past and is most commonly measured to describe nutrient intake. It has generally been concluded that prepartum nutrition is more important than postpartum nutrition in determining the postpartum interval (Dunn and Kaltenbach, 1980; Dziuk and Bellows, 1983). Body condition scores have been used as an indirect measure of nutrient reserves and subjectively indicate the energy status of the cow (Lowman et al., 1973; Wiltbank et al., 1962). Dziuk and Bellows (1983) and Richards et al. (1986) have suggested a minimum body condition score greater than or equal to 5 at calving. This recommendation is made to insure that body stores are adequate for postpartum reproductive performance.

Other researchers have found that postpartum body weight/condition gain or loss determines postpartum rebreeding

performance (Rutter and Randel, 1984; Somerville et al., 1979; Rakestraw et al., 1986). Houghton et al. (1990) found that pre- and postpartum energy levels fed interacted to affect postpartum anestrous. Cows which were fed low energy intake prepartum followed by a higher intake postpartum had fewer days ($P < .05$) to first estrus than all other energy combinations. Richardson et al. (1976) suggested that rebreeding performance is related more to an actual body weight at breeding, rather than the rate of change in body weight from calving to breeding. Somerville et al. (1979), on the other hand, indicated that body weight loss postpartum was more important than a fixed body weight in determining rebreeding performance. Richards et al. (1986) suggested that cows with a body condition score of four or less at calving had a higher cumulative percentage exhibiting estrus by day 20, 40, and 60 of the period when fed a high, moderate or low/flush nutritional regime, compared to those fed a low nutrient intake. This suggests that cows in thin condition will still breed back if flushed or fed a high nutrient intake. Louw and Thomas (1988) also found that cows will become cyclic when fed a diet for weight gain after they became acyclic due to severe weight loss. Wiltbank et al. (1962) found it difficult to explain similarities in the indicators of estrus between groups fed high and low levels of energy pre- and post calving. Cows fed low energy seemed to have adequate follicular development to promote estrus, but

did not cycle. Houghton et al. (1990) showed that cattle in fleshy condition may have a shorter postpartum interval, but their first service conception rates were lower than thin and moderately fleshed cows.

It appears nutrition plays a significant role influencing postpartum interval; however, the mechanism(s) have yet to be revealed. Feeding energy to achieve specific body condition scores may mask the actual required nutrient or nutrients which are specifically needed for successful postpartum reproduction. Discretion must be used in the interpretation of body condition score or energy status as it relates to postpartum fertility. These measures may, or may not, be cause and effect, but simply correlated events.

Circulating LH is low immediately following parturition (Arije et al. 1974), and the frequency and amplitude of LH pulses increase with the onset of the first postpartum estrus. This increase in LH, synchronized with FSH, stimulates follicle maturation and is brought about by increasing concentrations of estradiol-17 β (Hafez 1985). The pre-ovulatory rise in estrogen induces LH release through gonadotropin releasing hormone (GnRH) in the hypothalamus (Beck and Convey, 1977). The mechanisms by which nutrition impacts this system are under investigation.

Suckling has been demonstrated to inhibit the release of LH in the postpartum beef cow (Short, et al., 1972; Wright, et al., 1987). Calf separation at birth (Short, et al. 1972), or

at some time prior to first estrous (Walters, et al. 1982), will influence the return to estrus within a few days. The suckling effect in these studies was thought to act similarly to progesterone in inhibiting LH secretion via the brain since the pituitary would still respond to a GnRH challenge. Early weaning is an accepted management practice adopted by the dairy industry and accelerates the return to first estrus. It would be difficult for range beef operations to institute this practice when maximizing the nutrient resource of the range and decreasing supplemental inputs.

Lactation, primarily in first lactation heifers, greatly influences the return to estrus due to the requirements needed for it and growth (Whittier et al. 1988). Hunter and Magner (1988), concur with this observation. Harrison et al. (1989) has also attributed a suppression of estrous behavior to cows with high milk production. Bellows and Short (1978) found that by feeding high energy diets postpartum to cows fed a low plane of energy prepartum, days to first estrus were extended. They speculated that this may have stimulated milk production at the expense of reproduction. Hunter and Magner (1988) fed postpartum beef heifers a supplement composed of formaldehyde-treated casein, and found that supplemented heifers, returned to estrus 5 weeks earlier than unsupplemented heifers, had a faster rate of gain and a lower milk yield in the second half of a 16 week lactation period. They suggested nutrients were partitioned to cause a decrease of nutrients for milk

production while enhancing maternal realignment, thereby improving reproductive success.

Ionophores such as monensin have been shown to affect the postpartum interval of the beef cow (Turner et al., 1977; Belcher et al., 1980; Hardin and Randel, 1983; Mason and Randel, 1983). The proposed reasoning for the improvement in postpartum interval is the shift in volatile fatty acid (VFA) production to propionate without affecting total fatty acid production in the rumen. A shift in VFA production in monensin fed cows is suspected to be partly responsible for improved energy efficiency and feed utilization. If a shorter postpartum interval is an effect of increased ruminal propionate production then an increase in total energy intake should elicit the same response. This has not always been the case (Rutter and Randel, 1984; Richards et al. 1986; Randel, 1990), suggesting that the effect of monensin was, at best, only partially explained by altered VFA production.

Both endocrine and ovarian function have been manipulated with the quantity of fat in the diet (Williams, 1988; and Hightshoe et al. 1991). By increasing the lipid content of the diet postpartum, Williams (1988) found higher concentrations of progesterone during an induced cycle as well as a CL lifespan being nearly twice as long as those fed lower levels of lipid. Hightshoe et al. (1991) demonstrated that cows fed a postpartum supplement containing calcium soaps of fatty acids which escape degradation in the rumen had

increased concentrations of LH and enhanced follicle growth, in addition to greater progesterone concentrations also found by Williams (1988). It appears that these researchers are stimulating the reproductive processes in the postpartum beef cow by increasing the quantity of cholesterol for the synthesis of gonadotropin hormones which can then exert their effects on the hypothalamus. The cost, storage and delivery systems of these supplements are factors which may inhibit their acceptance by beef cow-calf range operations if other alternatives can be incorporated to achieve reproductive success.

Metabolizable protein intake can be confounded with energy intake or efficiency. Feeding ruminally degradable protein has also been shown to have a positive effect on reproduction (Sasser et al. 1988) when compared to feeding smaller quantities. As dry matter or energy intake increases there is an increase in microbial protein synthesis resulting in a greater amounts of protein presented to the small intestine for absorption. This could lead one to the alternate interpretation that reproductive responses, which have been previously attributed to increased energy intake, could also be due to an increase in metabolizable protein availability affected by increased ruminal microbial protein synthesis. Conversely, protein supplementation can cause increased dietary intake and forage digestibility (Raleigh and Wallace, 1963; Turner, 1985).

In earlier research, protein was not considered an important factor regulating reproductive success (Wiltbank et al. 1962). Recent research has indicated that reproduction is influenced by protein in the postpartum beef cow (Sasser et al. 1988). They fed protein at either restricted levels or adequate both pre and postpartum. Restricted levels of protein were shown to extend postpartum intervals and increase the days to conception. Nolan et al. (1988) attributed this response to reduced gonadotropin release from the anterior pituitary following an estradiol-17 β challenge. This could be due to a lack of estradiol receptors or improper storage or synthesis of GnRH within the hypothalamus.

There has been a greater research effort investigating protein nutrition as it relates to reproduction in the dairy cow. Ferguson and Chalupa (1989), in a review article, predicted from a computerized model that young cows, still growing, are more sensitive to absorbed amino acids than products from excess ruminal ammonia, ie. undegradable protein. Furthermore it is suggested that these young growing females tend to partition absorbed nutrients for growth rather than milk production (Hunter and Magner 1988; and Wiley et al. 1991). Mature cows will generally increase milk production rather than divert nutrients towards maternal tissues (Bellows and Short, 1978; Chalupa, 1984; Roffler and Thacker, 1983; Oldham, 1984). High concentrations of ruminally degradable protein in diets fed to older dairy cows has been shown to be

detrimental to reproduction. These diets are characterized by elevated ruminal ammonia, blood urea nitrogen and other nitrogenous compounds in body tissues. Impaired fertility has resulted from the toxic effects of urea on sperm and ova (Kaim et al. 1983).

Progesterone concentration in the midluteal phase of the cycle prior to breeding has been correlated with conception rate (Folman et al. 1973). Ferguson and Chalupa (1989) presented data from three separate studies (Jordan and Swanson, 1979; Blauwiekel et al., 1986; Snoderman et al., 1987) which showed a reduction in serum progesterone as crude protein increased from 13 to 15 percent, but changed little as crude protein increased from 15 to 20 percent. Folman et al. (1981) found that in isonitrogenous diets, type of protein influenced reproductive success postpartum. Cows fed a ruminally undegradable protein treatment had fewer breedings per conception and fewer days not pregnant than those cows fed a highly rumen degradable protein supplement. The site of protein utilization has also shown positive effects on reproductive parameters by shortening the postpartum interval of young beef cows and heifers (Hunter and Magner 1988; Halfpop et al. 1988; Wiley et al. 1991). These reports suggest that future studies must be designed to control energy status and protein source for studying and improving animal performance.

Protein plays a role in the P-450 enzyme systems which are involved in the production and catabolism of steroid hormones (Waterman et al., 1986; Rodgers et al., 1986; Jefcoate, 1986; Singh et al., 1988; Thomford and Dziuk, 1988). Specific amino acids have been shown to stimulate these enzyme systems (Truex et al. 1977). This stimulation could be one explanation of how protein supplementation influences reproduction (Smith 1988). Specific amino acids have not been accounted for in previous studies which may explain a portion of the variation of the effects of nutrition on reproduction. A well controlled experimental design must be adapted before an assessment of supplementation with excess protein or specific amino acids can be made. Furthermore, because the cytochrome P-450 enzymes can be anabolic as well as catabolic with regards to steroid hormones, additional studies are needed to find out the specific nutrients that will affect synthesis and regulation.

The metabolic status of a cow changes, particularly in adipose tissue, as she approaches parturition to prepare for lactation. In late pregnancy and early lactation, insulin and glucose are unable to alter the basal and catecholamine-stimulated rates of lipolysis (Metz and van den Bergh, 1977). High concentrations of growth hormone, (GH), during lactation are believed to facilitate the diversion of nutrients, at least glucose and lipid, to the mammary gland (Hart 1983). Although the mechanism for this effect is not known, one

aspect of it deals with GH inducing insulin-resistance in maternal tissues. In lactating animals, insulin secretory responses to glucose and propionate are reduced (Lomax et al. 1979). These adaptations in metabolism have been hypothesized to ensure that milk production is maintained.

It is clear pregnancy and lactation complicate metabolic regulation since milk production and fetal growth are not directly regulated by maternal hormones (Brockman and Laarveld, 1986). Since glucose uptake by the uterus and mammary gland is concentration-dependent, maternal nutrient status improves when nutrient absorption exceeds fetal and/or mammary tissue demands. Hunter and Magner (1988) postulate that, by increasing the insulin levels of beef heifers postpartum with undegradable protein, they could over compensate for the desensitization of insulin by GH, thus maternal tissues would respond to the repartitioning of nutrients.

Harrison and Randel (1986) measured the effect of energy restrictions on beef heifers and found exogenous insulin increased ovulation rates in energy-deprived heifers. Cox et al. (1987) found that exogenous insulin increased ovulation rate in gilts. Plasma insulin levels have been shown to be affected by dietary energy intake (Bassett 1974), dietary protein intake (Hunter and Magner 1988), body condition (McCann and Reimers 1985), and milk production (Butler and Canfield 1989). These factors have also been implicated in

achieving reproductive success. Furthermore, intravenous infusions of amino acids, abomasal infusions of casein and increased dietary intake of crude protein have been shown to increase serum insulin concentrations (Oldham, 1984; Chew et al., 1984; Blauwiel and Kincaid, 1986; Cohick et al. 1986). Adashi et al. (1980) demonstrated that increased concentrations of insulin in tissue cultures of pituitary and luteal cells increased the output of FSH and progesterone. Insulin has also been shown to play a role in steroid hormone production (Veldhuis et al., 1986).

Because propionate is the major glucogenic source of energy derived from ruminal fermentation in the ruminant animal, insulin is more responsive to circulating levels of propionate than glucose (Van Soest, 1987). Luteinizing hormone (LH) characteristics were unaffected in postpartum beef cows infused with high levels of glucose (McCaughey et al. 1988). When these cows were administered a spike treatment of glucose there was a corresponding increase in insulin but this insulin increase rapidly declined to baseline concentrations. Since low circulating serum concentrations of glucose are common in the ruminant (Mayes, 1988), this metabolite is more closely regulated and conserved especially in the postpartum cow. A slower release of nutrients, as with the case of undegradable protein, would be expected to sustain a higher endogenous insulin level throughout the supplementation period. In addition,

supplementation of a concentrated energy source to cattle grazing winter and spring range may be less advantageous due to the amount required on a daily basis, reduction in range utilization and possible increase in labor and/or facilities needed.

Protein effects on reproduction in the postpartum beef cow have been demonstrated, but have yet to be explained. Since GH concentration is comparatively higher in the lactating beef cow and initiates insulin-resistance in maternal tissues, it would be antagonistic to the effect of insulin on lipogenesis, however it facilitates insulin's protein synthetic effects (Brockman and Laarveld, 1986). Protein which can by-pass the rumen could stimulate insulin release over a longer period of time. This extended release could help overcome maternal tissue resistance to insulin manifested by GH. With insulin potentially increasing maternal growth and enabling cows to achieve a positive weight gain, reproductive responses could be improved (Somerville et al., 1979; Roberson et al., 1989). This suggests that by feeding undegradable protein postpartum, the beef cow could utilize the protein to increase and extend the circulating insulin level thus increasing steroid hormone production with an earlier return to first estrus.

CHAPTER 3

MATERIALS AND METHODS

Two experiments using a 2 x 2 factorial arrangement of treatments and one experiment using a 3 x 2 factorial arrangement of treatments were used to evaluate the effect of pre and postpartum protein supplementation on beef cows grazing winter and spring range (Figure 2). In experiments one and two, two prepartum supplements were fed originating from cubed alfalfa or canola meal at 1.82 kg/hd every-other-day from December 5, 1990 until just prior to calving. They were formulated to be iso-nitrogenous (20% crude protein). In the third experiment cows were supplemented prepartum to achieve different weight gains. All supplements were individually fed and contained 3.2 kg/hd beet pulp fed on alternate days. Two supplements contained an additional source of protein from either alfalfa sun-cured cubes or canola meal pellets (20% CP), and was fed at 1.82 kg/hd on alternate days. The third supplement which was formulated to allow for minimal weight gain consisted only of beet pulp.

Mature cows were assigned to either the first or second experiment by calving date (Early vs. Late), while in the third experiment all three year old cows were used.

Experiment one, late calving cows: Sixty six multiparous crossbred beef cows ranging from four to 10 years of age, approximately 562 kg, and made up of primarily Hereford and Angus breeding, were randomly assigned to one of two dietary

protein treatments as they calved (March 20 to April 23, 1991). Cows assigned to the first treatment (RD) received a protein supplement formulated to supply .371 kg ruminally degraded protein and .119 kg undegraded protein $\text{hd}^{-1} \text{d}^{-1}$. The second postpartum supplement (UD) was formulated to supply .245 kg of ruminally degraded protein and an equal amount of ruminally undegraded protein per $\text{hd}^{-1} \text{d}^{-1}$. Supplements were individually fed beginning two to five days after calving and continued up to the breeding season on alternate days at a rate of 1.82 kg per head. The last day postpartum supplements were fed was June 3, 1991. They were formulated to be iso-nitrogenous and nearly iso-energetic (Table 3). Supplements were mixed in two batches (Farr Better Feeds, Billings MT). The first batch was fed from the beginning of the study through May 19 (Table 1), and the second batch was fed from May 20 to May 28. The second batch of supplement was similar to the first batch (crude protein on an as-fed basis, 47.83% and 45.73% for UD and RD supplements respectively). Disappearance rates for dry matter and protein of the supplements were estimated in situ (Figure 1). This confirmed that the degradability of the protein was different between supplements with more protein and dry matter of feed origin being presented to the small intestine over time from the UD supplement. Cows were fed a trace mineral and salt supplement free choice and had free access to water throughout the study.

The supplementation period prior to breeding was

conducted in a 256.6 ha pasture at the Red Bluff Research Ranch, located 56 km west of Bozeman Montana. Annual precipitation averages from 350 to 406 mm (USDA-SCS, 1976). Carrying capacity was estimated at 1.21 ha animal⁻¹ unit month (AUM; Payne, 1973). Major grass species (Turner, 1985) include blue bunch wheat-grass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), prairie junegrass (*Koeleria pyramidata*), and needle and thread (*Stipa comata*).

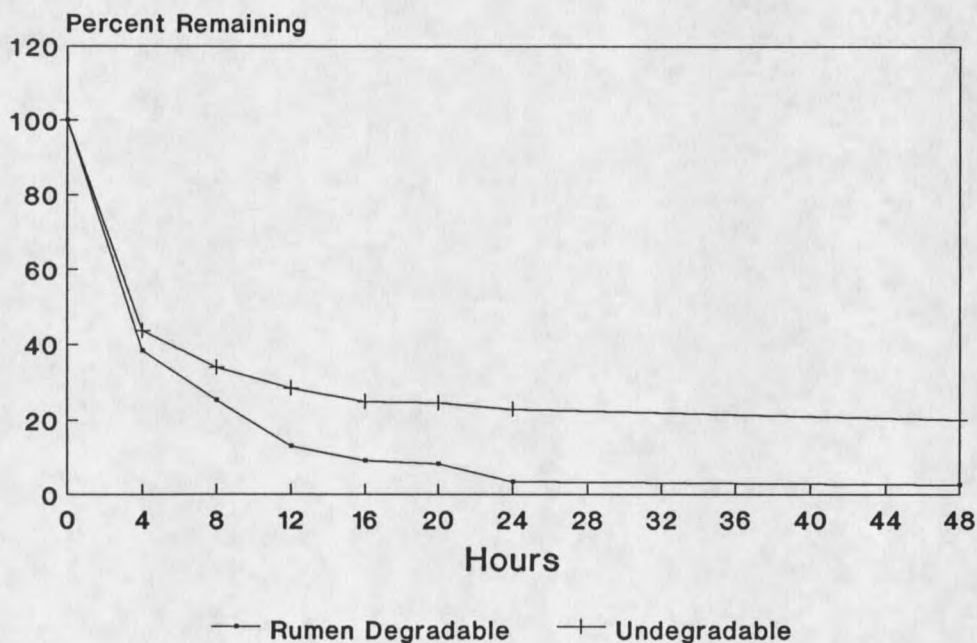


Figure 1: In situ dry matter disappearance rate describing ruminally degradable and ruminally undegradable protein supplements over 48 hours.

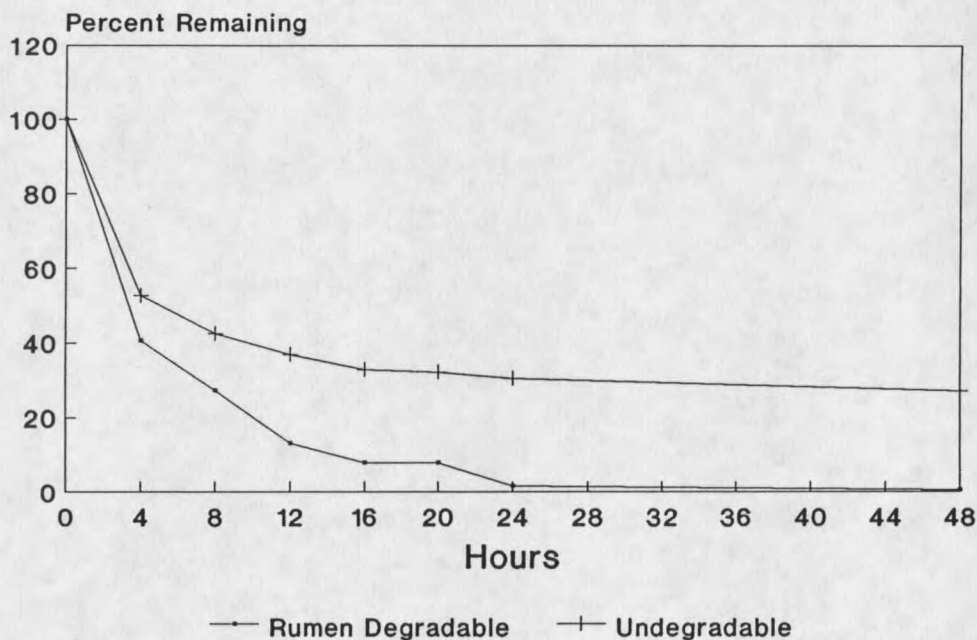


Figure 2: In situ protein disappearance rate describing ruminally degradable and ruminally undegradable protein supplements over 48 hours.

TABLE 1: FORMULATION OF PROTEIN SUPPLEMENTS FOR RUMINALLY DEGRADABLE (RD) AND UNDEGRADABLE (UD).

Ingredient	RD %	UD %
Soybean oil meal	66.00	35.00
Wheat mill run	22.00	29.50
Urea	2.00	-----
Ammonium phosp.	2.50	2.00
Molasses	6.50	6.50
Potassium chlor.	1.00	1.00
Feathermeal	-----	13.00
Blood meal	-----	13.00
Vitamin A	22,500 IU/.454 kg	22,500 IU/.454 kg

Condition scores (1 = emaciated, 9 = obese) palpated by two technicians, and cow weights were recorded on Dec. 5, 1990; prior to calving, March 5, 1991; at branding May 22, 1991 and at the end of the study, Aug. 16, 1991.

Ruminal extrusa samples were collected from two cannulated cows fed 1.82 kg/hd of supplement every-other-day, which was made up of 50% RD and 50% UD supplement. Collections were made April 30, 1991 and on May 28, 1991 in order to evaluate the grazed range forage during the postpartum period prior to breeding. Ruminal contents were evacuated and cows allowed to graze for one hour. The extrusa was then collected, air dried, ground through a 2 mm screen and prepared for lab analyses (Table 2).

TABLE 2: LAB ANALYSIS OF RUMEN EXTRUSA SAMPLES COLLECTED ON DAY 36 AND 64 FROM TWO COWS.

Percent As-Fed	Dry Matter	Crude Protein	NDF	ADIN
Day 36	91.66	5.82	66.75	.55
Day 64	89.35	12.47	56.25	.73

Ten ml of blood were collected from cows via venous/arterial puncture of the tail, centrifuged at 2000 rpm within one hour after collection and the serum frozen until later analysis by solid-phase RIA for progesterone concentrations. Serum collections began at approximately 26 days postpartum, and were continued at four day intervals until the breeding season. First estrus postpartum was determined by serum progesterone levels greater than

1 ng ml⁻¹. Intra- and inter assay coefficients of variance were 10.3% and 3.2% respectively.

Blood samples were collected by the procedure described above on day 39 and 53 of the study for analysis of serum metabolites and insulin concentrations. Blood metabolites measured included; blood urea nitrogen, (BUN), serum albumin, cholesterol, and plasma glucose. On days 39 and 53 milk production was estimated by using a six hour weigh-suckle-weigh technique (Ansotegui 1986).

Fecal output was measured by administering CapTec¹ chromic oxide slow-release boluses to 50 cows on day 27 and collecting fecal grab samples on days 35, 37 and 39. Samples were immediately frozen until later lab analysis. After samples were thawed, dry matter and organic matter were determined by AOAC (1975) procedures. The remainder of the sample was ground through a 2mm screen. Chromic oxide concentration was determined by analyzing duplicate subsamples using the atomic absorption spectrophotometry technique (Williams et al., 1962). Fecal output was estimated from grab samples based on the percentage chromium in the feces on an organic matter (OM) basis.

Supplementation was terminated on June 2, 1991 and cows moved to a 130.3 hectare pasture for breeding.

¹81 Carlton Gore Road, Newmarket, Box 759, Auckland, New Zealand.

The breeding season began on June 3, 1991, with the first 21 days utilizing artificial insemination. Semen from two Angus and two Hereford sires was collected and assigned to cows based on the cows genetic make-up. Cows were observed for behavioral estrus twice daily in the pasture and bred approximately 12 hours after detection of estrus. After breeding cows were moved to an adjacent 257 hectare pasture and exposed to four Hereford bulls (1:41 bull to cow ratio) for the remainder of the breeding season. Cows not exhibiting estrus in the first 21 days were placed with the bulls following the AI period. Bulls were removed from the pasture and the 46 day breeding season terminated on July 19, 1991.

TABLE 3: RUMINALLY DEGRADABLE (RD) AND RUMINALLY UNDEGRADABLE (UD) PROTEIN SUPPLEMENT CHEMICAL ANALYSIS. (AS FED BASIS)

Analysis	RD %	UD %
Dry Matter	85.94	88.37
Protein	46.59	47.80
RD protein	35.28	23.90
UD protein	11.31	23.90
TDN	86.36	81.72
ADF	3.52	6.37
Ether Extract	.50	1.53
ADIN	.40	2.66

Data collection ended on August 16, 1991. Cows were condition scored and tested for pregnancy via rectal palpation. Both cows and calves were weighed.

Experiment two, early calving cows: Experiment two was conducted similarly to experiment one with these modifications. Sixty two of the early calving crossbred beef cows, approximately 570 kg, from the Red Bluff Research ranch were randomly assigned to one of two pastures adjacent to Exp. 1, (approx. 159 hectares each), after calving. The calving period ranged from March 4, to March 20, 1991. On March 25, 1991 supplementation was initiated with the RD supplement group fed to cows in one pasture and UD supplement group fed to cows in the other pasture at a rate of 1.82 kg/hd every-other-day. These supplements were identical to those fed to the late calving cows in Exp. 1. The number of days which supplement was fed (66) was the same for all cows. In addition, cows were fed approximately 4.5 kg of mixed grass hay (10.5% crude protein DM basis) $\text{hd}^{-1} \text{d}^{-1}$ to May 18, 1991. Hay feeding was used to minimize confounding of supplement and pasture affects. Cows were rotated between the two pastures every eight days as another method to reduce confounding.

Estrous cyclicity prior to the breeding season was estimated by detection of an ovarian corpus luteum via rectal palpation on May 22, 1991 and then again on May 30, 1991. Postpartum cow weights were measured on May 22, 1991.

Supplementation was terminated on May 30, 1991. Cows from Exp. one and Exp. two were combined and moved to the same pasture for detection of estrus and artificial insemination.

Cows in Exp. one and two were treated similarly throughout the remainder of the trial.

Experiment three, three year old cows: Experiment three was conducted similarly to Exp. 2 with these exceptions. Forty three-year-old crossbred cows, approximately 533 kg, were fed three prepartum dietary supplements (as previously described) at the Montana State University Livestock Center in Bozeman, MT. The cows were delivered immediately post-calving to the Red Bluff ranch facilities. Cows were randomly assigned to postpartum supplemental regimes and were mixed with cows from Exp. two. Cattle fed supplements in Exp. two and three were co-mingled throughout the postpartum period.

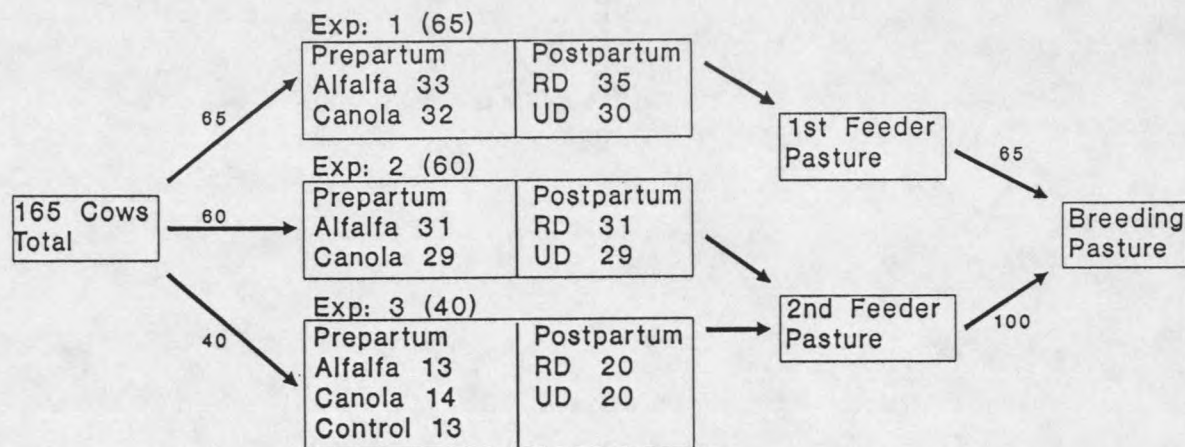
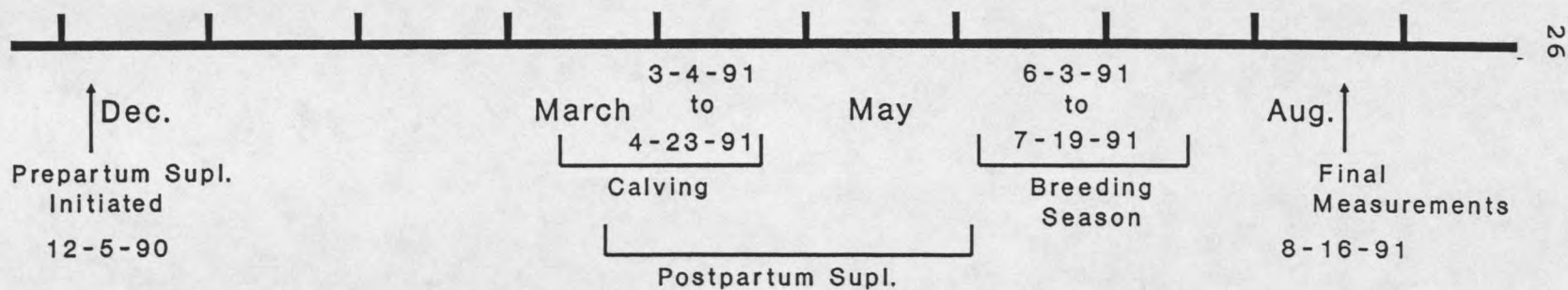


Figure 3. Experimental design and chronological order of the study.

Statistical Analysis

December and March cow weights, condition scores and their changes were analyzed with General Linear Models (GLM) analysis of variance of SAS (SAS 1988). Prepartum supplement was used as a class variable in the model and initial December cow weights or condition scores were used as co-variates within their respective analysis when analyzing March data and weight change from December to March. Postpartum cow weights, condition scores and their respective changes during the postpartum period, were also analyzed with analysis of variance GLM of SAS. Prepartum and postpartum supplement, prepartum by postpartum supplement interaction, the date of calving classified by groups, and calving group by postpartum treatment interaction were class variables. Calving date was defined in Exp. one by arranging cows into three groups (group one, March 20 to March 26, 1991; group two, March 27 to April 7, 1991; and group three, April 8 to April 23, 1991). Initial December measurements were used as their respective co-variates unless proven non-significant in which case they were deleted from the model. Calving date was used in the analysis to account for days on supplement in experiment one and three. Experiment two used the same model; however, all cows were fed supplement for identical days.

Fecal output was evaluated with GLM of SAS with pre- and postpartum supplementation and their interaction in the model.

Pre- and postpartum supplements and their interaction

were used as class variables in the model for analyzing preweaning calf gain. Calf age was used as a co-variate in all experiments. Calf birth weight was used as a co-variate in Exp. two.

The GLM multivariate repeated measures analysis of variance was used for the analysis of milk production for late calving cows in Exp. one. Class variables included pre- and postpartum supplements and their interactions and sex of calf.

Insulin concentrations and blood metabolites were analyzed using the multivariate repeated measures GLM analysis of SAS with pre- and postpartum supplements and their interaction included as factors in the model.

Prepartum and postpartum supplements, their interaction, cowage and postpartum supplement by cowage interaction, calving group and calving group by postpartum supplement were used as factors in the model analyzing the number of days to first estrus in experiment one.

Pregnancy rate, percent serviced in the first 21 days of the breeding season for all experiments and percent cycling prior to the breeding season in experiment's one and two, were analyzed using the Chi-square procedure of SAS with pre- and postpartum supplements, and prepartum by postpartum supplement interaction as factors.

CHAPTER 4

RESULTS AND DISCUSSION

Prepartum Weight and Condition Score Change

Prepartum protein source significantly influenced prepartum weight change ($P < .001$, $.001$, $.04$) in experiments one, two and three respectively. Cows fed canola meal gained more weight prior to calving in all experiments when compared to those fed alfalfa (21 kg, 22 kg and 10 kg for cows in experiments one, two and three respectively, Table 4). Three-year-old cows fed a beet pulp based supplement prepartum maintained weight postpartum while allowing for fetal growth. Condition scores for three-year-old cows were unaffected by prepartum protein source with all cows losing approximately one condition score prior to the calving season. Mature cows in experiments one and two lost less condition ($.2$ and $.3$, $P < .10$ and $P < .003$, respectively) when fed canola supplement prepartum.

Postpartum Weight and Condition Score Change

Prepartum supplementation had no effect on postpartum weight change in experiments two and three but was significant in experiment one ($P < .02$).² Calving date was a significant factor ($P = .07$) for cow weight change from calving to the breeding season in experiment one. The late calving cows that calved in group three lost less weight (14

²(See appendix Table 24 for affect of prepartum supplementation on postpartum gain.)

kg and 11 kg ± 4) than cows which calved in group one or two, respectively. This could probably be attributed to the fact that later calving cows had less time in which they could lose weight postpartum. The interaction between calving group and postpartum supplement was not significant in any of the experiments. Calving date was not significant in either experiment one or two.

Cow weight change prior to breeding was affected by postpartum protein source in the early calving cows and three-year-olds while the late calving cows fed either supplement showed similar weight losses (Table 5). Cows in Exp. two and Exp. three that were group fed supplement and received 4.5 kg of hay $\text{hd}^{-1} \text{ day}^{-1}$ had less weight loss when fed the UD supplement (Table 5) ($P < .001$). This is in agreement with Hibberd et al. (1988) who also used supplements that were iso-nitrogenous and Wiley et al. (1991) who fed bypass protein in addition to the ruminally degradable quantity. Although insulin concentrations were not measured in Exp. two and three, the results could be related to the findings of Hunter and Magner (1988). They proposed that cows fed ruminally undegraded supplement that had higher insulin concentrations may partition nutrients away from milk production to other tissues in favor of maternal growth. Carcass composition of lactating sows was affected by protein intake with sows losing more muscle tissue when fed diets low in crude protein Brendemul et al. (1989). Bailey (1989) concluded that steers

consuming a forage diet when fed undegradable protein had a higher rate of gain and increase in muscle and protein tissue. These studies also suggest that protein tissue, consequently body weight, may be conserved when undegradable protein supplement is fed postpartum. Rutter and Randel (1984) suggested that the direction of body weight change dictates reproductive success. Roberson et al. (1989) proposed that secretion of gonadotropins is influenced by the direction of body weight change since both FSH and LH increased in those heifers that were gaining weight.

The later calving cows fed either UD or RD supplement in Exp. one which received no hay postpartum showed the same weight loss prior to the breeding season. Based upon diet quality estimated from the ruminal extrusa samples (Table 2), multiplied by the organic matter intake, it appears that CP intake was inadequate ($1205 \text{ g hd}^{-1} \text{ d}^{-1}$) up until April 30, 1991 and more likely this deficiency extended to May, compared to NRC (1984) recommendations ($1300 \text{ g hd}^{-1} \text{ d}^{-1}$) for a beef cow with the milking ability demonstrated in Exp. one.

TABLE 4. THE EFFECT OF PREPARTUM PROTEIN SUPPLEMENTATION ON BEEF COW WEIGHT (WT) AND CONDITION SCORE (CS) PRIOR TO PARTURITION.^a

	<u>Experiment one</u>			<u>Experiment two</u>			<u>Experiment three</u>			
	Alf	Can	SE ^b	Alf	Can	SE ^b	Alf	Can	Cont	SE ^b
December										
wt (kg)	564.1	559.8	8.1	570.9	568.7	10.1	536.4	527.2	539.0	12.5
cs	4.7	4.5	.13	4.7	4.9	.15	4.8	5.0	5.1	.17
March										
wt (kg) ^c	588.9	609.9*	2.5	588.0	609.9*	2.9	545.1	555.1	533.9*	3.3
cs ^d	3.9	4.0*	.07	3.7	4.0*	.06	4.0	3.9	3.8	.10
Change ^e										
wt (kg) ^f	26.9	47.9*	2.5	17.7	39.6*	2.9	10.9	21.4	-0.4*	3.3
cs ^g	-.8	-.6*	.07	-1.1	-.8*	.06	-1.0	-1.1	-1.2	.10

^aExperiment one = Late calving cows; Experiment two = Early calving cows; Experiment three = 3 year old cows. Alf = Alfalfa, Can = Canola, Cont = Control supplement

^bSE = pooled standard error of LSmeans

^cExperiment one and two, Alf vs Can, $P < .001$; Experiment three, Alf vs Can $P < .04$, Alf vs Cont $P < .03$, Can vs Cont $P < .001$

^dExperiment one, Alfalfa vs Canola, $P < .10$; Experiment two, Alfalfa vs Canola, $P < .01$

^eChange = change from December to March

^fExperiment one and two, Alfalfa vs Canola, $P < .001$; Experiment three, Control vs Canola,

$P < .001$, Control vs Alfalfa, $P < .024$, Alfalfa vs Canola, $P < .04$

^gExperiment one, Alfalfa vs Canola, $P < .10$; Experiment two, Alfalfa vs Canola, $P < .003$

TABLE 5. THE EFFECT OF POSTPARTUM PROTEIN SUPPLEMENTATION ON BEEF COW WEIGHT (WT) AND CONDITION SCORE (CS) POST CALVING.^{ab}

Item	<u>Experiment one</u>			<u>Experiment two</u>			<u>Experiment three</u>		
	RD	UD	SE ^c	RD	UD	SE ^c	RD	UD	SE ^c
May									
wt (kg) ^d	546.9	552.1	4.4	524.3	563.3*	4.7	466.4	491.0*	4.2
cs	4.2	4.2	.07	4.1	4.2	.07	3.9	3.8	.07
August									
wt (kg)	579.0	578.8	4.4	581.9	579.8	3.9	525.6	519.3	6.6
cs	4.8	4.7	.07	4.8	4.8	.09	4.8	4.6	.10
Mar-May ^e									
wt (kg) ^d	-48.7	-54.4	3.3	-74.8	-31.1*	3.8	-77.4	-53.5*	3.7
cs	.3	.3	.08	.2	.3	.10	.0	.0	.09
May-Aug ^f									
wt (kg) ^d	31.6	26.3	3.4	58.7	17.2*	3.5	61.3	30.0*	4.9
cs	.7	.5	.08	.7	.5	.09	.8	.8	.10

^aExperiment one = late calving cows; Experiment two = early calving cows;

Experiment three = 3 year old cows.

^bRD = Ruminally Degradable supplement, UD = Ruminally Undegradable supplement

^cSE = pooled standard error of LSmeans

^dExperiment two and three, RD vs UD, P < .001

^eDifference in March to May measurements

^fDifference in May to August measurements (LSMeans)

This deficiency of intake protein may have caused suboptimal production of microbial protein from the rumen and resulted in suboptimal energy and protein status of the cow, particularly in cows receiving the UD supplement. This agrees with Murphy et al. (1991) who also suggested that range supplements formulated with bypass protein may reduce ruminal function and thus compromise potential cow performance. Hibberd et al. (1988) formulated postpartum supplements that contained 643 g of CP with 322 g of ruminally degradable protein. This compares to 245 g ruminally degradable protein in our UD supplement and 371 g in our RD supplements. This greater quantity of ruminally degradable protein may explain the responses to the supplements reported by Hibberd et al. (1988), and the lack of a differential response between the RD and UD supplemented cows in the late calving group in Exp. one. The UD supplement was formulated to contain 150 g per day less rumen degradable protein than the RD supplement. Although the escape protein provided by the UD supplement could increase the flow of protein to the small intestine, as evident by protein disappearance rates (Figure 1b), it may have failed to allow for maximal protein synthesis and fermentation in the rumen (Murphy et al. 1991). The net effect was there being no gain or increase in protein flowing to the small intestine with the UD supplement, as previously demonstrated by Schloesser (1991).

There were no differences in condition score changes during the postpartum period due to postpartum protein supplementation in any of the experiments. Calving date did not affect condition score changes postpartum in any of the experiments. Prepartum protein supplement affected May condition scores in experiment one, two and three ($P < .04$, $P < .008$, $P < .09$, respectively) Table 24. The analysis of variance for body condition score differences was sensitive to small numerical differences. These differences, however, phenotypically would be virtually impossible to detect, and biologically are difficult to explain.

Fecal Output: (Late Calving Cows)

Fecal output measured on day 35, 37 and 39 postpartum with the late calving cows in Exp. one was similar for each supplement group. If it is assumed that digestibility was not influenced by supplement, then organic matter intake was also similar (Table 6).

TABLE 6. AVERAGE FECAL OUTPUT OF INDIVIDUALLY FED COWS RECEIVING EITHER RD OR UD SUPPLEMENT POSTPARTUM. (N = 40)

Treatment	Fecal Output	SE
RD, g	2724.5	± 157.7
UD, g	2510.5	± 171.6

Several experiments have shown that protein supplementation of diets containing low protein levels will increase dietary intake (Clanton 1981, Turner 1985). This effect has been suggested to be a result of positive effects on microbial digestion (Campling et al. 1962, Egan 1965).

Egan (1965) has also shown increases in intake when casein was infused into the duodenum. Others have not shown predictable increases in dietary intake with protein supplementation (Raleigh and Wallace, 1963, Turner 1985). The contradictions of research findings may be due to differences in the relative proportion of protein fraction and (or) the protein quantity consumed. One benefit of feeding an undegradable protein supplement is greater true digestibility of proteins of high biological value compared to the digestibility of crude protein from the rumen microbes (Van Soest 1983). This would lead to the assumption that in the current study one of two factors may have controlled animal responses: 1) ruminal function was the same for both UD and RD supplements with no effect on intake, (however, it has already been suggested that ruminal function may have been suboptimal in cows fed UD supplement), 2) ruminal function was more favorable in the RD fed cows but the addition of escape protein in the UD fed cows compensated for the lower level of ruminal protein production.

Milk Production: (Late Calving Cows)

Milk production (Fig. 3), measured with cows in Exp. one, was not affected by either prepartum or postpartum protein supplementation. A trend for calf sex to influence milk production ($P = .11$) was observed. No influence by the ruminal degradability of the protein supplement on milk production agrees with the work of Wiley et al. (1991) and up to day 60 postpartum reported by Hunter and Magner (1988).

There was a significant calf sex by time interaction with dams of bull calves milking $3.3 \text{ kg} \pm .9$ less on day 39 than dams of heifer calves, while on day 53 milk production was similar between dams of either sex (10.9 kg and $10.6 \text{ kg} \pm .9$ for dams of bull and heifer calves, respectively). There appears to be no biological explanation for this.

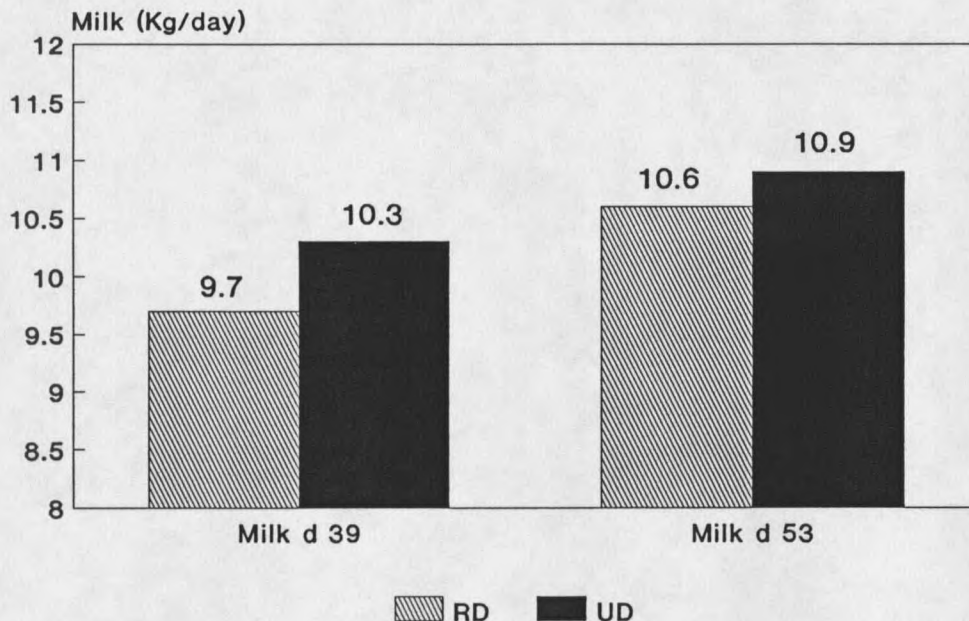


Figure 4. Milk production estimated on day 39 and 53 in Exp. 1. Postpartum protein effect ($P > .33$). ($N = 52$) Standard errors for RD and UD on day 39 and 53 are: .88, 1.01, .83 and .95, respectively.

Prewaning Calf Gains

Age of calf was a significant factor affecting calf gains in each Exp., ($P < .001$ for Exp. 1 and Exp. 3, and ($P < .003$ for gains in Exp. two. Pre- or postpartum supplementation did not significantly affect preweaning gain in Exp. 1 and 2, (Fig. 4) however, prepartum supplement influenced preweaning calf gain in three year old cows ($P < .03$). On August 16,

1991 calves gained 131.8 kg from cows which received alfalfa prepartum compared to 116.3 and 115.4 kg calves from cows receiving canola or beet pulp prepartum, respectively. This may be explained by those cows that received alfalfa prepartum having lower maintenance requirements which would favor a greater fraction of metabolizable nutrients available for milk production (Imakawa et al. 1986). Conversely, cows that were fed the negative control supplement may have been restricted at such a level that postpartum nutrients were required for maternal growth in addition to milk production (Brendemuhl et al. 1989). Since milk production was unaffected by pre and postpartum supplementation in Exp. one, it would be expected that preweaning gain would also be unaffected.

In previous studies where varying levels of energy were fed pre- and postpartum (Houghton et al. 1990) and postpartum (Richards et al. 1986) researchers have shown differences in preweaning calf gains. Sasser et al. (1988) and Wiltbank et al. (1965) by feeding CP deficient diets pre- and postcalving proposed that this effect was due to reduced milk production. Other researchers (Rakestraw et al. 1986) who fed different amounts of protein and forage postpartum, and Wiley et al. (1991) who fed RD vs. UD protein supplements postpartum found no significant effects on preweaning calf gains due to postpartum treatments.

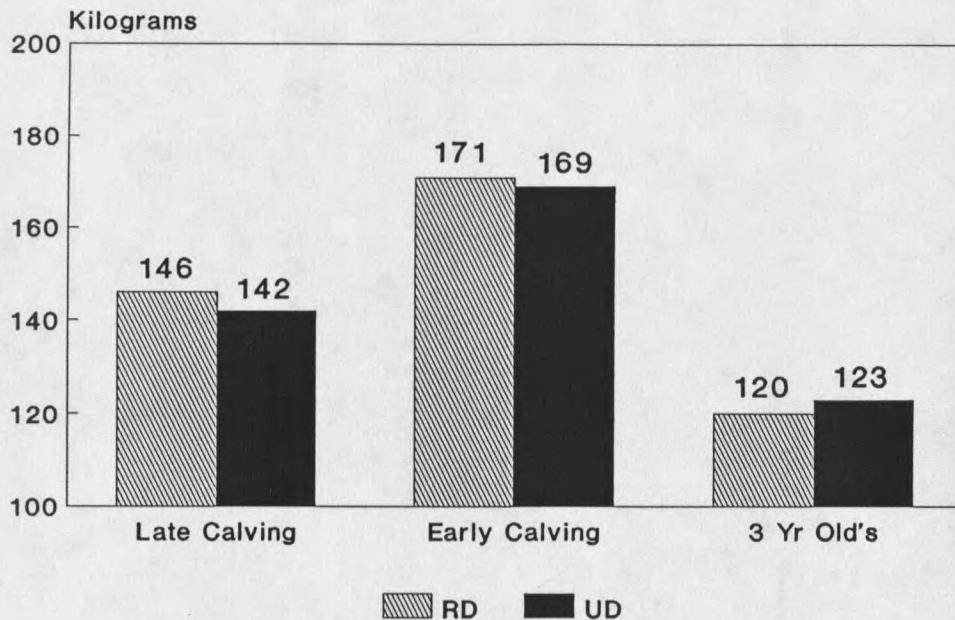


Figure 5. Preweaning calf gain for Exp. one, two and three. Pooled SE = 2.7, 2.9 and 3.4 respectively. Postpartum treatment effects ($P = .23, .53$ and $.52$) respectively. ($N = 63, 58$ and 36 for Exp. one, two and three respectively)

Blood Metabolites: (Late Calving Cows)

Albumin and glucose were unaffected by prepartum and postpartum protein supplementation (Table 7). Cows fed alfalfa protein supplement prepartum had higher serum cholesterol concentrations at day 39 than cows fed canola ($P < .06$). On day 39 and 53, BUN concentrations were higher for cows receiving UD supplement vs RD supplement ($P = .10$ and $P < .01$), respectively. This is in agreement with Wiley et al. (1991) however the concentrations observed in that study were 30% higher than in the current study. Higher BUN concentrations can be a result of either low dietary protein intake with subsequent tissue catabolism and negative nitrogen

balance or from protein in excess of requirements thus causing deamination in the rumen or the liver or when excess non protein nitrogen is fed. Preston et al. (1965) found that diets which were isonitrogenous produced higher urea nitrogen concentrations when digestible energy was low. This could be a factor in the current study as there was less protein available to the rumen for the UD supplement fed cows.

TABLE 7. THE EFFECT OF PRE AND POSTPARTUM PROTEIN SUPPLEMENTATION ON BLOOD METABOLITES OF BEEF COWS POST CALVING (N = 65).

Measurement	Treatment ^a				SE ^b
	Alf	Can	RD	UD	
BUN (mg/dl)					
d 39 ^c	10.15	10.49	9.75	10.90*	.49
d 53 ^d	13.95	13.88	13.07	14.76*	.45
Cholesterol (mg/dl)					
d 39 ^e	119.38	111.26*	115.41	115.23	2.93
d 53	119.77	113.73	118.40	115.10	2.96
Albumin (mg/dl)					
d 39	4.10	4.09	4.09	4.11	.05
d 53	3.89	3.84	3.85	3.88	.04
Glucose (mg/dl)					
d 39	63.71	63.50	63.22	64.00	.82
d 53	58.79	59.75	59.75	58.80	.93

^aAlf = Alfalfa Pretreatment, Can = Canola Pretreatment, RD = rumen degradable postpartum supplement, UD = rumen undegradable postpartum supplement

^bSE = pooled standard error of LSmeans

^cRD vs UD, P < .11

^dRD vs UD, P < .01

^eAlf. vs Can., P < .06

Serum cholesterol concentration was higher on day 39 for cows fed alfalfa supplement prepartum (Table 7; P < .06) than those fed canola and a trend numerically to be higher on day

53. This agrees with Wiley et al. (1991), who fed maintenance and low prepartum levels of nutrition to two year old heifers and found those fed on a low plane of nutrition prepartum tended to have higher concentrations of cholesterol postpartum.

Insulin Concentrations: (Late Calving Cows)

A significant prepartum x postpartum supplement interaction ($P = .03$) for insulin concentrations was found. Cows that were fed UD protein supplement postpartum had higher concentrations of insulin when fed the prepartum canola protein supplement. Cows that received the RD protein supplement postpartum had higher insulin concentrations when alfalfa was the prepartum protein source (Table 8). Since the model used explained less than 6% of the variation it would be difficult to put much weight into these measurements to explain the differences by pre- or postpartum protein supplementation. McCann and Reimers (1985) reported that thin heifers had lower insulin concentrations than obese heifers. This helps explain the higher concentrations of cows fed canola prepartum and UD protein postpartum but does not help explain the high concentration for cows fed alfalfa prepartum and RD supplement postpartum. However, the cows in the current study did not differ in condition score (Table 4 and 5) and this may be the reason for the interaction. Insulin was sampled approximately 40 hours after supplementation so the effects of protein absorption may be minimal as suggested

by Lalman et al. (1991). Both Wiley et al. (1991) and Hunter and Magner (1988) fed supplements daily which perhaps enabled them to measure ruminally undegradable protein affects on insulin concentrations.

TABLE 8. THE EFFECT OF PRE- AND POSTPARTUM SUPPLEMENTS ON INSULIN CONCENTRATIONS (NG/DL), OF LATE CALVING COWS IN EXPERIMENT ONE.^a

Prepartum	<u>Postpartum Treatment^b</u>		SE ^c
	<u>RD</u>	<u>UD</u>	
Alfalfa	.55	.50	.03
Canola	.50	.60	.03

^a(P = .03)

^bRD = rumen degradable postpartum supplement, UD = rumen undegradable postpartum supplement

^cSE = pooled standard error of LSmeans

Hunter and Magner (1988) and Wiley et al. (1991) found a rise in insulin concentrations later in the postpartum period for heifers fed a ruminally undegradable protein supplement. This delay in the increased insulin concentrations may have been due to the induced insulin-resistance that growth hormone (GH) has on maternal tissues (Hart 1983). The high concentrations of GH during lactation (Hart 1983, Hunter and Magner 1988) are believed to facilitate the diversion of nutrients, at least glucose and lipid, to the mammary gland.

Days to Estrus: (Late Calving Cows)

The interval from calving to first estrus in the late calving cows was significantly affected by postpartum supplement, cow age and calving date, (P < .04, P < .001, P <

.01), respectively. A significant postpartum supplement x cowage interaction was also found ($P < .04$). Four year old and 10 year old cows expressed their first estrous cycle earlier when fed the RD supplement. Cows fed RD supplement exhibited their first estrus nine days earlier (47) than those fed UD supplement (56) (Table 9). Richards et al. (1985) found that differences in postpartum energy intake had no significant effect on interval to estrus, but body condition caused numerical differences for cows with a 4 or less body condition score (61 d) compared to cows scored with a 5 body condition score (49 d).

Prepartum protein supplement did not significantly influence days to first estrus in late calving cows. This disagrees with research conducted with cows fed differing energy intake (Houghton et al. 1990; Wiley et al. 1991) and causing weight loss. In the current study both prepartum treatments produced gains in the prepartum period. Four year old cows that were fed RD or UD supplement reached their first estrus later (65 vs. 37-56) than middle aged cows (5-9) that were fed RD or UD supplement. Although four year old cows with their 3rd calf may be expected to perform as a mature cow, this study indicates that they may still have requirements for maternal growth similar to younger cows. Since supplements were individually fed the effect of dominance on intake should have been eliminated in the late calving cows.

Percent Cycling Prior to Breeding Season

Early calving cows: The percentage of early calving cows cycling prior to breeding was unaffected by pre- and postpartum supplementation. One hundred percent of the cows fed UD protein postpartum were cyclic prior to the breeding season compared to 97 percent of the cows fed RD supplement. Although differences in weight change were found due to postpartum supplement, cows cycled efficiently prior to breeding. This may have been at the expense of the three year old cows since supplement was group fed and dominance displayed by the mature cows throughout the postpartum period may have increased their intake while decreasing supplement intake of three year old's.

Three year old cows: The percent of 3 year old's cycling prior to the breeding season, as determined by rectal palpation for an ovarian CL, was significantly higher for those fed RD postpartum supplement ($P < .04$) than cows fed UD supplement (Table 9). This does not agree with work done in dairy cows (Menge et al. 1962; and Stevenson and Britt 1980). They concluded that percent change in body weight was inversely related to days to first estrus. In the present study three year old cows fed UD protein supplement postpartum lost less weight from March to May (55 kg vs. 78 for UD vs. RD fed cows).

Percent Serviced in 21 days

Late calving cows: The effect of postpartum protein supplementation on the number of cows bred in the first 21 days approached significance for the late calving cows, with 100% of those cows receiving UD supplement serviced, and 91% serviced of cows fed RD supplement ($P < .11$). Prepartum supplementation had no influences on the late calving cows.

Early calving cows: All early calving cows were serviced in the first 21 days of the breeding season and were thus unaffected by prepartum or postpartum supplementation (Table 9).

Three year old cows: Three year old cows receiving the control supplement prepartum had 54.5% serviced in the AI portion of the breeding season compared to 85% and 83% of the canola and alfalfa fed cows, respectively. Although they were not different statistically, more than likely due to low numbers within treatments, this is a very important economic trait to beef cattle producers and deserves discussion. Prepartum nutrition affecting postpartum reproduction is in agreement with previous work (Corah et al. 1974; Bellows and Short 1978; Wettemann et al. 1982), but is not in agreement with Wiley et al. (1991) who found prepartum nutrition had no effect on percent bred in the first 21 days of the breeding season. This might be explained by the fact that postpartum protein and TDN were provided in excess of NRC (1984) requirements where as in the current study postpartum

nutrition was based upon the availability of native range production and may not have provided the nutrients to reduce the prepartum effects. Observations of reduced supplement intake by three year old's during the postpartum period were made and may account for the lack of reproduction efficiency.

Pregnancy Rate

Fall pregnancy rate was not affected by either prepartum or postpartum protein source in all experiments. Early calving cows fed alfalfa prepartum did show a numerically lower pregnancy rate than their canola fed herdmates (Table 9), but it was not significant. This is in agreement with Wiley et al. (1991). When protein has been deficient postpartum it has caused lower pregnancy rates (Hancock et al. 1984; Forero et al. 1980), however in the current study treatments were formulated to be isonitrogenous.

TABLE 9. THE EFFECT OF PRE AND POSTPARTUM PROTEIN SUPPLEMENTATION ON PERCENT CYCLING PRIOR TO THE BREEDING SEASON (CYCL), DAYS TO FIRST ESTRUS (DTE), PERCENT SERVICED IN THE FIRST 21 DAYS OF THE BREEDING SEASON (21D) AND PERCENT PREGNANT (PREG).^a

Item	Late			Early			3 year old		
	DTE	21D	Preg	Cycl	21d	Preg	Cycl	21d	Preg
Cows	64	63	63	58	58	58	36	36	36
Prepartum									
alfalfa	55	97	84	97	100	79 ^b	67	83	100
canola	50	94	90	100	100	93	92	85	85
control	--	--	--	--	--	--	64	55	73
Postpartum									
RD	49 ^c	91 ^d	86	97	100	83	89 ^e	79	89
UD	57	100	89	100	100	89	59	71	82

^aDTE analysis ANOVA (LSmeans); Cycl, 21d, and Preg analysis Chi-square

^balfalfa vs canola, $P < .13$

^cRD vs UD, $P < .06$

^dRD vs UD, $P < .11$

^eRD vs UD, $P < .03$

Reproductive Efficiency

The reproductive efficiency of this experimental cow herd was at a level in which it would be extremely difficult to improve. In fact, for statistically significant differences to be found a negative control should have been included in the study, but unfortunately this was not possible. Although reproductive traits may be successfully predicted due to the differences in magnitude of weight change, all mature cows cycled and rebred efficiently and appeared to be unaffected by differences or magnitude of weight change. This may be illustrated by examining the reproductive performance of the early calving cows in Exp. two that were group fed. They were exposed to the best of conditions. They were fed supplement longer and therefore had more time to exhibit estrus. They were also observed to intimidate the younger three year old cows and probably consumed more than the expected amount of supplement (1.82 kg hd^{-1}). These cows also received 4.5 kg of hay each day. By comparison the late calving cows had fewer days to cycle, were not fed hay and were individually fed supplement, but had equal reproductive performance as the early calving cows. This may indicate that lactating cows grazing spring range do not require any hay feeding (with a cow herd possessing the reproductive traits of these animals).

Three year old cows did exhibit differences in reproductive parameters but low numbers per treatment, and lack of control of postpartum supplement intake, make

interpretation difficult. A more controlled design would be advantageous to evaluate nutritional treatments with younger females that are still growing.

CHAPTER 5

CONCLUSION

These experiments demonstrated that cow weight change postpartum can be affected by feeding a supplement containing ruminally undegradable protein vs ruminally degradable protein when 4.5 kg of hay $\text{hd}^{-1} \text{d}^{-1}$ was fed to beef cows grazing spring native range. Prepartum supplementation did not significantly influence postpartum weight change. Cows receiving a one-half ration of medium quality hay $\text{hd}^{-1} \text{d}^{-1}$ postpartum had less weight loss when fed 1.82 kg every-other-day of a ruminally undegradable protein supplement vs. an isonitrogenous ruminally degradable protein supplement.

Prepartum supplementation did not affect fecal output, milk production, calf preweaning gain, days to first estrus in late calving cows, or cyclicity in early calving or three year old cows in addition to overall fall pregnancy rates.

Late calving cows in Exp. one that were fed ruminally degradable supplement postpartum had fewer days to first estrus than cows fed the ruminally undegradable supplement. However, the percent of cows serviced in the first 21 days of the breeding season and overall pregnancy rates, which are the most important traits economically, were not different between cows fed the two supplements and were similar in all experiments. Metabolic status of the late calving cows indicated by blood metabolites showed similar nutritional states for cows fed either postpartum supplement. However,

blood urea nitrogen was higher for cows fed the ruminally undegradable protein supplement. Insulin concentration was affected by an interaction between prepartum and postpartum supplementation; however, there appears to be little biological significance.

It can be stated from the results of these experiments that when adequate protein is provided in the diet for optimal rumen function, addition of ruminally undegraded protein to the diet will decrease weight loss of the postpartum cow grazing native spring range. If beef cows have been supplemented with a 20% CP protein supplement during the last trimester of gestation, they may be reproductively successful if they receive a 50% crude protein supplement containing either a 50:50 or 30:70 ratio of UD to RD protein while grazing spring range and nursing a calf.

LITERATURE CITED

- Adashi, E. Y., A. J. W. Hsueh, and S. S. C. Yen. 1980. Insulin enhancement of luteinizing hormone and follicle stimulating hormone released by cultured pituitary cells. *Endocrinology* 108:1441.
- Ansotegui, R. P. 1986. Chemical composition and rumen digesta kinetics of diets selected and influence of milk intake on forage intake by suckling calves grazing native range. Ph.D. Dissertation. New Mexico State Univ., Las Cruces.
- Arije, G. R., J. N. Wiltbank and M. L. Hopwood. 1974. Hormone levels in pre- and post-parturient beef cows. *J. Anim. Sci.* 39:338.
- Bailey, C B. 1989. Rate and efficiency of gain, from weaning to slaughter, of steers given hay, hay supplemented with ruminal undegradable protein, or concentrate. *Can. J. Anim. Sci.* 69:691-705.
- Bassett, J. M. 1974. Diurnal patterns of plasma insulin, growth hormone corticosteroid and metabolite concentrations in fed and fasted sheep. *Aust. J. Biol. Sci.* 27:167-181.
- Beck, T. W. and Convey, E. M. 1977. Estradiol control of serum luteinizing hormone concentrations in the bovine. *J. Anim. Sci.* 46:181-188.
- Belcher, D. R., R. D. Wyatt, S. W. Coleman, R. L. Hintz, G. L. Crosthwait and S. L. Armbruster. 1980. Effect of monensin on reproductive performance and winter weight change of fall-calving, first-calf heifers. *Oklahoma Agric. Exp. Sta. MP-107:68.*
- Bellows, R. A. and R. E. Short. 1978. Effects of precalving feed level on birth weight, calving difficulty and subsequent fertility. *J. Anim. Sci.* 46:1522.
- Blauwiel, R., and R. L. Kincaid. 1986. Effect of crude protein and solubility on performance and blood constituents of dairy cows. *J. Dairy Sci.* 69:2091.
- Blauwiel, R., R. L. Kincaid and J. J. Reeves. 1986. Effect of high crude protein on pituitary and ovarian function in Holstein cows. *J. Dairy Sci.* 69:439.
- Brendemuhl, J. H., A. J. Lewis and e. R. Peo, Jr. 1989. Influence of energy and protein intake during lactation on body composition of primiparous sows. *J. Anim. Sci.* 67:1478.

- Brockman, R. P. and B. Laarveld. 1986. Hormonal regulation of metabolism in ruminants. *Livest. Prod. Sci.* 14:313.
- Butler, W. R. and R. W. Canfield. 1989. Interrelationships between energy balance, reproduction of lactating dairy cows examined. *Feedstuffs.* 52:18.
- Campling, R. C., M. Freer, and C. C. Balch. 1962. Factors affecting the voluntary intake of food by cows. *Brit. J. Nutr.* 20:25.
- Chalupa, W. 1984. Discussion of protein symposium. *J. Dairy Sci.* 67:1134.
- Chew, B. P., J. R. Eiseman, and T. S. Tanaka. 1984. Arginine infusion stimulates prolactin, growth hormone, insulin and subsequent lactation in pregnant dairy cows. *J. Dairy Sci.* 67:2507.
- Clanton, D. C. 1981. Crude protein system in range supplements. In: Owens, A. L. ed. Protein Symposium. Oklahoma State Univ. p. 10.
- Cohick, W. S., J. L. Vicini, C. R. Staples, J. H. Clark, S. N. McCutcheon, and D. E. Bauman. 1986. Effects of intake and postruminal casein infusion on performance and concentrations of hormones in plasma of lactating cows. *J. Dairy Sci.* 69:3022.
- Corah, L. R., A. P. Quealy, T. G. Dunn and C. C. Kaltenbach. 1974. Prepartum and postpartum levels of progesterone and estradiol in beef heifers fed two levels of energy. *J. Anim. Sci.* 39:380.
- Cox, N. M., M. J. Stewart, T. G. Althun, W. A. Bennett and H. W. Miller. 1987. Enhancement of ovulation rate in gilts by increasing dietary energy and administering insulin during follicular growth. *J. Anim. Sci.* 64:507.
- Dickerson, G. 1969. Efficiency of animal production-molding the biological components. *J. Anim. Sci.* 30:849.
- Dunn, T. G., J. E. Ingalls, D. R. Zimmerman and J. N. Wiltbank. 1969. Reproductive performance of 2-year-old Hereford and Angus heifers as influenced by pre- and post-calving energy intake. *J. Anim. Sci.* 29:719.
- Dunn, T. G. and C. C. Kaltenbach. 1980. Nutrition and the postpartum interval of the ewe, sow and cow. *J. Anim. Sci.* (Suppl. 2) 51:29.

- Dziuk, P. J. and R. A. Bellows. 1983. Management of reproduction of beef cattle, sheep and pigs. *J. Anim. Sci.* 57 (Suppl. 2):355.
- Egan, A. R. 1965. Nutritional status and intake regulation in sheep. The relationship between improvement of nitrogen status and increase in voluntary intake of low-protein roughage by sheep. *Aust. J. Agr. Res.* 16:463.
- Ferguson, J. D. and W. Chalupa. 1989. Interactions of nutrition and reproduction: Impact of Protein Nutrition on Reproduction in Dairy Cows. *J. Dairy Sci.* 72:746.
- Folman, Y., M. Rosenberg, Z. Herz, and M. Davidson. 1973. The relationship between plasma progesterone concentration and conception in postpartum dairy cows maintained on two levels of nutrition. *J. Reprod. Fertil.* 34:267.
- Folman, Y., H. Neumark, M. Kaim, and W. Kaufmann. 1981. Performance, rumen and blood metabolites in high-yielding cows fed varying protein percents and protected soybean. *J. Dairy Sci.* 64:759.
- Forero, O., F. N. Owens and K. S. Lusby. 1980. Evaluation of slow-release urea for winter supplementation of lactating range cows. *Oklahoma Agric. Exp. Sta. MP-116:323.*
- Hafez, E. S. E. 1985. Reproductive cycles: In Reproduction of Farm Animals. I. S. I. Hafez ed. Lea and Febiger, Phil., Penn.
- Halfpop, P. J., M. K. Petersen, R. A. Bellows and M. J. McInerney. 1988. Protein supplementation of lactating beef heifers. *Proc. Mont. Livestock Nutr. Conf.* 39:18.
- Hancock, K. L., J. R. Kropp, K. S. Lusby, R. P. Wettemann, D. S. Buchanan and C. Worthington. 1984. The influence of postpartum nutrition and weaning age of calves on cow body condition, estrus, conception rate and calf performance of fall-calving beef cows. *Oklahoma Agric. Exp. Sta. MP-117:180.*
- Hardin, D. R. and R. D. Randel. 1983. Effect of monensin on postpartum interval to first estrus and serum LH response to 0, 1, 2 or 4 mg estradiol-17 β at 21 days postpartum. *Theriogenology* 19:343.

- Harrison, L. M. and R. A. Randel. 1986. Influence of insulin and energy intake on ovulation rate, luteinizing hormone and progesterone in beef heifers. *J. Anim. Sci.* 63:1228.
- Harrison, R. O., J. W. Young, A. E. Freeman and S. P. Ford. 1989. Effects of lactational level on reactivation of ovarian function, and interval from parturition to first visual oestrus and conception in high-producing Holstein cows. *Anim. Prod.* 49:23.
- Hart, I. C. 1983. Endocrine control of nutrient partition in lactating ruminants. *Proc. Nutr. Soc.* 42:181-194.
- Hibberd, C. A., R. R. Scott, B. D. Trautman and C. Worthington. 1988. Bypass protein supplementation of lactating beef cows grazing dormant native grass in winter. *Proc. Annu. Meet. West. Sect. Am. Soc. Anim. Sci.* 39:324.
- Hightshoe, R. B., C. Cochran, L. R. Corah, G. H. Kiracofe, D. L. Harmon and R. C. Perry. 1991. Effects of calcium soaps of fatty acids on postpartum reproductive function in beef cows. *J. Anim. Sci.* 69:4097.
- Houghton, P. L., R. P. Lemenager, L. A. Horstman, K. S. Hendrix and G. E. Moss. 1990. Effects of body composition, pre- and postpartum energy level and early weaning on reproductive performance of beef cows and preweaning calf gain. *J. Anim. Sci.* 68:1438.
- Hunter, R. A. and T. Magner. 1988. The effects of formaldehyde-treated casein on the partitioning of nutrients between cow and calf in lactating *Bos Indicus* x *Bos Taurus* heifers fed a roughage diet. *Aust. J. Agric. Res.* 39:1151.
- Imakawa, K., Day, M. L., Garcia-Winder, M., Zalesky, D. D., Kittok, R. J., Schanbacher, B. D. and Kinder, J. E. 1986. Endocrine changes during restoration of estrous cycles following induction of anestrus by restricted nutrient intake in beef heifers. *J. Anim. Sci.* 63:565.
- Jefcoate, Colin R. 1986. Cytochrome P-450 enzymes in sterol biosynthesis and metabolism. In *Cytochrome P-450*, P. R. Ortiz de Montellano, ed., Plenum Press, New York, pp 387.
- Jordan, E. R. and L. V. Swanson. 1979. Serum progesterone and luteinizing hormone in dairy cattle fed varying levels of crude protein. *J. Anim. Sci.* 48:1154.

- Kaim, M., Y. Folman, H. Neumark and W. Kaufmann. 1983. The effect of protein intake and lactation number on postpartum body weight loss and reproductive performance of dairy cows. *Anim. Prod.* 37:229.
- Lalman, D., M. K. Petersen, R. P. Ansotegui, M. Tess, C. K. Clark, and J. S. Wiley. 1991. The effects of ruminally undegradable protein, propionic acid and monensin on puberty and reproductive efficiency in beef heifers. *Proc. Annu. Meet. West. Sect. Am. Soc. Anim. Sci.* 42:
- Lowmax, M. A., G. D. Baird, C. B. Mallinson and H. W. Symonds. 1979. Differences between lactating and non-lactating dairy cows in concentration and secretion rate of insulin. *Biochem. J.* 180:281.
- Louw, B. P. and C. R. Thomas. 1988. The influence of loss and gain of body mass on ovarian activity in beef cows. *S. Afr. J. Anim. Sci.* 18:1.
- Lowman, B. G., N. Scott and S. Somerville. 1973. Condition scoring of cattle. *E. of Scotland Coll. of Agric. Bull.* No. 6.
- Mason, G. L. and R. D. Randel. 1983. Effect of monensin and suckling on the GnRH induced luteinizing hormone surge and the effect of monensin on the postpartum interval in Brangus cows. *Theriogenology* 19:331.
- Mayes, P. A. 1988, *Regulation of Carbohydrate Metabolism In Harper's Biochemistry.* Appleton and Lange Norwalk, Connecticut.
- McCann, J. P. and T. J. Reimers. 1985. Glucose response to exogenous insulin and kinetics of insulin metabolism in obese and lean heifers. *J. Anim. Sci.* 61:612.
- McCaughey, W. P., L. M. Rutter, and J. G. Manns. 1988. Effect of glucose infusion on metabolic and reproductive function in postpartum beef cows. *Can. J. Anim. Sci.* 68:1079.
- Menge, A. C., S. E. Mares, W. J. Tyler and L. E. Casida. 1962. Variation and association among postpartum reproduction and production characteristics in Holstein-Friesian cattle. *J. Dairy Sci.* 45:233.
- Metz, H. M. and van den Bergh, S. G. 1977. Regulation of fat mobilization in adipose tissue of dairy cows in the period around parturition. *Neth. J. Agric. Sci.* 25:198-211.

- Murphy, T. M., K. S. Lusby and R. P. Wettemann. 1991. Feather meal in winter supplements for beef cows. Oklahoma Agric. Exp. Sta. pp 184.
- Nolan, C. J., R. C. Bull, R. G. Sasser, C. A. Ruder, P. M. Panlasiqui, H. M. Schoeneman and J. J. Reeves. 1988. Postpartum reproduction in protein restricted beef cows: Effect on the hypothalamic-pituitary-ovarian axis. J. Anim. Sci. 33:1026.
- NRC. 1984. Nutrient requirements of beef cattle (6th ed.). National Academy Press, Washington, D. C.
- Oldham, J. D. 1984. Protein-energy interrelationships in cows. J. Dairy Sci. 67:1090.
- Payne, G. F. 1973 Vegetative rangeland types in Montana. Montana Agr. Exp. Sta. Bull. No. 671.
- Preston, R. L., D. D. Schnakenberg and W. H. Pfander. 1965. Protein utilization in ruminants I. blood urea nitrogen as affected by protein intake. J. Nutr. 86:281.
- Rakestraw, J., K. S. Lundsby, R. P. Wettemann and J. J. Wagner. 1986. Postpartum weight and body condition loss and performance of fall-calving cows. Theriogenology 26:461
- Raleigh, R. J., and J. D. Wallace. 1963. Effect of supplementation on intake of grazing animals. Proc. West. Sec. Am. Soc. Anim. Sci. 14:XXVII.
- Randel, R. D. 1990. Nutrition and postpartum rebreeding in cattle. J. Anim. Sci. 68:853.
- Richards, M. W., J. C. Spitzer and M. B. Warner. 1985. Effect of varying levels of postpartum nutrition and body condition at calving on subsequent reproductive performance in beef cattle. J. Anim. Sci. 62:300.
- Richardson, F. D., J. Oliver and G.P.V. Clarke. 1976. Analysis of some factors which affect the productivity of beef cows and of their calves in a marginal rainfall area of Rhodesia. 1. Factors affecting calving rate. Anim. Prod. 24:41.
- Roberson, M. S., T. T. Stumpf, M. W. Wolfe, R. J. Kittok and J. E. Kinder. 1989. Influence of body weight change on secretion of gonadotropins in the ovariectomized beef heifer. J. Anim. Sci. 67:(Supp. 1) 386. (abstract)

- Rodgers, R. J., H. F. Rodgers, M. R. Waterman, E. R. Simpson. 1986. Immunolocalization of cholesterol side-chain-cleavage cytochrome P-450 and ultrastructural studies of bovine corpora lutea. *J. Reprod. Fert.*, 78:639.
- Roffler, L. D., and D. L. Thacker. 1983. Early lactational response to supplemental protein by dairy cows fed grass-legume forage. *J. Dairy Sci.* 66:2100.
- Rutter, L. M., and R. D. Randel. 1984. Postpartum nutrient intake and body condition: Effect on pituitary function and onset of estrus in beef cattle. *J. Anim. Sci.* 58:265-273.
- SAS. 1988. Statistical analysis system. SAS Institute Inc. Raleigh, North Carolina.
- Sasser, R. G., R. J. Williams, R. C. Bull, C. A. Ruder and D. G. Falk. 1988. Postpartum reproductive performance in crude protein-restricted beef cows: Return to estrus and conception. *J. Anim. Sci.* 66:3033.
- Schloesser, B. J., V. M. Thomas, M. K. Petersen, R. W. Kott and P. G. Hatfield. 1991. The effects of substituting blood meal for soybean meal on nutritional status of gestating ewes. Masters Thesis, Mont. St. Univ.
- Short, R. E., R. A. Bellows, R. B. Staigmiller, J. G. Berardinelli and E. E. Custer. 1990. Physiological mechanisms controlling anestrus and infertility in postpartum beef cattle. *J. Anim. Sci.* 68:799.
- Short, R. E., R. A. Bellows, E. L. Moody and B. E. Howland. 1972. Effects of suckling and mastectomy on bovine postpartum reproduction. *J. Anim. Sci.* 34:70.
- Singh, Y. V., K. Chaudhary, R. Bhatnagar and U. K. Misra. 1988. Mixed function oxidases in response to quality and quantity of dietary protein. *Biochem. Intern.* 17:1.
- Smith, J. F. 1988. Influence of nutrition on ovulation rate in the ewe. *Aust. J. Biol. Sci.* 41:13.
- Snoderman, J. P., G. E. Weaver, and L. L. Larson. 1987. Effect of dietary protein level and exogenous gonadotropin releasing hormone on circulating progesterone concentrations in lactating Holstein cows. *J. Dairy Sci.* 70(Suppl. 1):183. (Abstr).

- Stevenson, J. S. and J. H. Britt. 1980. Models for prediction of days to first ovulation based on changes in endocrine and nonendocrine traits during the first two weeks postpartum in Holstein cows. *J. Anim. Sci.* 50:103.
- Sommerville, S. H., B. G. Lowman and D. W. Deas. 1979. The effect of plane of nutrition during lactation on the reproductive performance of beef cows. *Vet. Rec.* 104:95.
- Thomford, P. J. and P. J. Dziuk. 1988. Influence of phenobarbital dosage, dietary crude protein level and interval to measurement on hepatic monooxygenase activity in ewes. *J. Anim. Sci.* 66:1446.
- Truex, C. R., L. Brattsten, W. J. Visek. 1977. Changes in the mixed function oxidase enzymes as a result of individual amino acid deficiencies. *Biochem. Pharm.* 26:667.
- Turner, H. A., R. J. Raleigh and D. C. Young. 1977. Effect of monensin on feed efficiency for maintaining gestating mature cows wintered on meadow hay. *J. Anim. Sci.* 44:338.
- Turner, M. E. 1985. The forage intake of supplemented cows grazing winter foothill rangelands of Montana. M.S. Thesis, Montana State University, Bozeman.
- USDA-SCS. 1976. Climax vegetation in Montana: based on soils and climate. USDA-SCS. Bozeman, Montana.
- Van Soest, P. J. 1983. Nutritional Ecology of the Ruminant. O&B Books, Inc., Corvallis.
- Van Soest, P. J. 1987. Nutritional Ecology of the Ruminant. Cornell University Press, Ithaca, New York.
- Veldhuis, J. D., R. J. Rodgers, A. Dee and E. R. Simpson. 1986. The insulin-like growth factor, somatomedin C, induces the synthesis of cholesterol side-chain cleavage cytochrome P-450 and adrenodoxin in ovarian cells. *J. Biol. Chem.* 261:2499.
- Walters, D. L., R. E. Short, E. M. Convey, R. B. Staigmiller, T. G. Dunn and C. C. Kaltenbach. 1982b. Pituitary and ovarian function in postpartum beef cows. II. Endocrine changes prior to ovulation in suckled and nonsuckled postpartum cows compared to cycling cows. *Biol. Reprod.* 26:647.

- Waterman, M. R., E. J. Maleyahal, E. R. Simpson. 1986. Regulation of synthesis and activity of cytochrome P-450 enzymes in physiological pathways. In Cytochrome P-450, P. R. Ortiz de Montellano, ed., Plenum Press, New York. pp. 345.
- Wettemann, R. P., K. S. Lusby and E. J. Turman. 1982. Relationship between changes in prepartum weight and condition and reproductive performance of range cows. Oklahoma Agric. Exp. Sta. MP-107:176.
- Wettemann, R. P., B. M. Hill, M. E. Boyd, J. C. Spitzer, D. W. Forrest, and W. E. Beal. 1986. Reproductive performance of postpartum beef cows after short-term calf separation and dietary energy and protein supplementation. Theriogenology. 26:433.
- Whitman, R. W. 1975. Weight change, body condition and beef-cow reproduction. Ph.D. Dissertation. Colorado State Univ., Fort Collins.
- Whittier, J. C., D. C. Clanton and G. H. Deutscher. 1988. Effect of postpartum levels of nutrition on productivity of 2-year-old heifers. Anim. Prod. 47:59.
- Wiley J. S., 1991. Production from first calf beef heifers fed a high or low level of prepartum nutrition and ruminally undegradable protein postpartum. Masters Thesis, Mont. St. Univ.
- Williams, C. H., D. S. David, and O. Iisamaa. 1962. The determination of chromic oxide in faeces samples by atomic absorption spectrophotometry. J. Agric. Sci. 59:381.
- Williams, G. L. 1989. Modulation of luteal activity in postpartum beef cows through changes in dietary lipid. J. Anim. Sci. 67:785.
- Williams, G. L. 1990. Suckling as a regulator of postpartum rebreeding in cattle: A Review. J. Anim. Sci. 68:831.
- Wiltbank, J. N., W. W. Rowden, J. E. Ingalls, K. E. Gregory and R. M. Koch. 1962. Effect of energy level on reproductive phenomena of mature Hereford cows. J. Anim. Sci. 21:219.
- Wiltbank, J. N., J. Bone, E. J. Warwick, R. E. David, A. C. Cook, W. L. Reynolds and M. W. Hazen. 1965. Influence of total feed and protein intake on reproductive performance in the beef female through second calving. USDA Tech. Bull. 1314.

Wright, I. A., S. M. Rhind, A. J. F. Russel, T. K. Whyte, A. J. McBean and S. R. McMillen. 1987. Effects of body condition, food intake and temporary calf separation on the duration of the post-partum anoestrus period and associated LH, FSH, and prolactin concentrations in beef cows. Anim. Prod. 45:395.

APPENDIX

TABLE 10. REPEATED MEASURES ANALYSIS OF VARIANCE FOR BLOOD UREA NITROGEN (BUN), SERUM CHOLESTEROL, AND SERUM ALBUMIN CONCENTRATION.

Source	df	<u>BUN</u>		P	<u>Cholesterol</u>			df	<u>Albumin</u>		P
		Mean	Square		df	Mean	P		Mean	Square	
Pretrt	1	.59		.81	1	1620.46	.09	1	.02		.64
Trt	1	65.11		.01	1	98.26	.67	1	.02		.68
Pretrt*Trt	1	1.26		.72	1	42.72	.78	1	.19		.18
Error	61	9.74			61	536.18		61	.10		
Time	1	417.41		<.01		65.82	.10	1	.69		<.01
Time*Pretrt	1	1.36		.59	1	34.47	.24	1	.01		.44
Time*Trt	1	2.38		.47	1	78.69	.08	1	.001		.82
Time*Pretrt*Trt	1	7.18		.21	1	6.07	.62	1	.0004		.89
Error (T)	61	4.53			61	24.27		61	.02		

TABLE 11. REPEATED MEASURES ANALYSIS OF VARIANCE FOR SERUM GLUCOSE AND INSULIN CONCENTRATIONS.

Source	df	<u>Glucose</u>		df	<u>Insulin</u>	
		Mean Square	P		Mean Square	P
Pretrt	1	4.56	.69	1	.02	.48
Trt	1	.24	.93	1	.02	.46
Pretrt*Trt	1	2.73	.76	1	.18	.03
Error	61	28.95		61	.04	
Time	1	606.53	<.01	1	.15	.07
Time*Pretrt	1	11.19	.46	1	.003	.80
Time*Trt	1	24.24	.28	1	.03	.41
Time*Pretrt*Trt	1	.10	.94	1	.0006	.90
Error (T)	61	20.68		61	.04	

TABLE 12. REPEATED MEASURES ANALYSIS OF VARIANCE FOR MILK PRODUCTION.

Source	df	Total Milk	P
		Mean Square	
Pretrt	1	6.780	.57
Trt	1	3.837	.67
Pretrt*Trt	1	29.103	.24
Calfsex	1	56.293	.11
Error	47	21.078	
Time	1	14.511	.41
Time*Pretrt	1	.002	.99
Time*Trt	1	.555	.87
Time*Pretrt*Trt	1	20.200	.33
Time*Calfsex	1	86.869	.05
Error (T)	47	21.276	

TABLE 13. ANALYSIS OF VARIANCE FOR PREWEANING CALF GAIN IN EXPERIMENT ONE, EXPERIMENT TWO AND EXPERIMENT THREE.

Source	df	<u>Experiment 1</u>		df	<u>Experiment 2</u>		df	<u>Experiment 3</u>	
		Mean Square	P		Mean Square	P		Mean Square	P
Pretrt	1	20.33	.76	1	.22	.97	1	903.89	.02
Trt	1	316.60	.23	1	98.44	.53	1	77.11	.52
Pretrt*Trt	1	536.47	.12	1	822.37	.07	1	287.66	.23
Calfage	1	5690.02	<.01	1	2626.88	<.01	1	3422.05	<.01
Birthweight	-	---	--	1	2901.66	<.01	-	---	--
Error	58	215.59		52	242.45		29	185.39	

TABLE 14. ANALYSIS OF VARIANCE FOR PREPARTUM (DECEMBER AND MARCH), COW CONDITION SCORES (CS) AND CONDITION SCORE CHANGE IN EXPERIMENT ONE, EXPERIMENT TWO AND EXPERIMENT THREE.

Source	df	<u>Experiment 1</u>		df	<u>Experiment 2</u>		df	<u>Experiment 3</u>	
		Mean Square	P		Mean Square	P		Mean Square	P
December									
Pretrt	1	.18	.57	1	.84	.25	2	.23	.53
Error	63	.55		58	.63		37	.37	
March									
Pretrt	1	.48	.10	1	1.17	<.01	2	.17	.27
December cs	1	8.38	<.01		11.68	<.01		2.52	<.01
Error	62	.17		56	.11		36	.12	
Prepartum cs change									
Pretrt	1	.48	.10	1	1.17	<.01	2	.17	.27
December cs	1	9.09	<.01	1	6.73	<.01	1	4.51	<.01
Error	62	.17		56	.12		36	.12	

TABLE 15. ANALYSIS OF VARIANCE FOR POSTPARTUM (MAY AND AUGUST), COW CONDITION SCORES (CS) IN EXPERIMENT ONE, EXPERIMENT TWO AND EXPERIMENT THREE.

Source	<u>Experiment 1</u>			<u>Experiment 2</u>			<u>Experiment 3</u>		
	df	Mean Square	P	df	Mean Square	P	df	Mean Square	P
May									
Pretprt	1	.554	.04	1	.783	<.01	2	.345	.06
Trt	1	.096	.38	1	.092	.35	1	.017	.32
Pretprt*trt	1	.106	.36	1	.176	.19	2	.237	.13
Calving grp	2	.221	.18	1	.152	.23	2	.012	.89
Trt*calving grp	2	.100	.45	1	<.001	.99	2	.144	.28
December cs	1	3.260	<.01	1	5.189	<.01	1	1.060	<.01
Error	56	.17		53	.102		29	.107	
August									
Pretprt	1	.047	.58	1	.230	.25	2	1.141	<.01
Trt	1	.159	.31	1	.030	.68	1	.376	.13
Pretprt*trt	1	.206	.25	1	.410	.13	2	.219	.27
Calving grp	2	.280	.17	1	.330	.17	2	.215	.27
Trt*calving grp	2	.289	.16	1	.238	.24	2	.042	.77
December cs	1	5.130	<.01	1	7.635	<.01	1	3.835	<.01
Error	56	.15		53	.169		27	.158	

TABLE 16. ANALYSIS OF VARIANCE FOR POSTPARTUM COW CONDITION SCORE (CS) CHANGES (MARCH-MAY) AND (MAY-AUGUST) IN EXPERIMENT ONE, EXPERIMENT TWO AND EXPERIMENT THREE.

Source	<u>Experiment 1</u>			<u>Experiment 2</u>			<u>Experiment 3</u>		
	df	Mean Square	P	df	Mean Square	P	df	Mean Square	P
Mar-May change									
Pretprt	1	.016	.79	1	.041	.65	2	.248	.25
Trt	1	.002	.92	1	.118	.44	1	.046	.61
Pretprt*trt	1	.040	.67	1	.234	.28	2	.230	.27
Calving grp	2	.075	.72	1	.275	.24	2	.244	.25
Trt*calving grp	2	.015	.93	1	.035	.68	2	.022	.88
December cs	1	1.116	.03	1	.950	.03	--	---	--
Error	56	.224		52	.200		30	.168	
May-Aug. change									
Pretprt	1	.332	.21	1	.109	.46	2	.396	.10
Trt	1	.454	.15	1	.281	.23	1	.043	.60
Pretprt*trt	1	.008	.84	1	.946	.03	2	.010	.94
Calving grp	2	.442	.13	1	.048	.62	2	.178	.33
Trt*calving grp	2	.114	.58	1	.356	.18	2	.092	.56
December cs	--	---	--	--	---	--	1	.865	.02
Error	56	.15		54	.169		27	.155	

TABLE 17. ANALYSIS OF VARIANCE FOR PREPARTUM (DECEMBER AND MARCH), COW WEIGHTS AND WEIGHT CHANGE IN EXPERIMENT ONE, EXPERIMENT TWO AND EXPERIMENT THREE.

		<u>Experiment 1</u>			<u>Experiment 2</u>			<u>Experiment 3</u>	
Source	df	Mean Square	P	df	Mean Square	P	df	Mean Square	P
December									
Pretrt	1	293.14	.72	1	75.31	.88	2	525.26	.78
Error	63	2124.64		58	3053.86		37	2083.38	
March									
Pretrt	1	7123.80	<.01	1	7066.04	<.01	2	1498.26	<.01
December cs	1	115587.14	<.01	1	138369.73	<.01	1	68982.73	<.01
Error	62	195.32		56	251.01		36	.12	
Prepartum cs change									
Pretrt	1	7123.80	<.01	1	7066.04	<.01	2	1608.82	<.01
December cs	1	669.62	.07	1	2315.81	<.01	--	---	--
Error	62	195.32		56	251.01		37	148.51	

TABLE 18. ANALYSIS OF VARIANCE FOR POSTPARTUM (MAY AND AUGUST), COW WEIGHT IN EXPERIMENT ONE, EXPERIMENT TWO AND EXPERIMENT THREE.

Source	<u>Experiment 1</u>			<u>Experiment 2</u>			<u>Experiment 3</u>		
	df	Mean Square	P	df	Mean Square	P	df	Mean Square	P
May									
Pretprt	1	1409.57	.11	1	3359.86	<.01	2	2552.08	<.01
Trt	1	355.69	.41	1	15464.44	<.01	1	5346.76	<.01
Pretprt*trt	1	115.19	.64	1	26.56	.81	2	121.65	.68
Calving grp	2	1899.93	.03	1	23.84	.82	2	269.73	.43
Trt*calving grp	2	536.40	.37	1	333.47	.39	2	194.53	.54
December cs	1	95620.83	<.01	1	113339.68	<.01	1	45820.00	<.01
Error	56	523.50		49	451.07		27	308.52	
August									
Pretprt	1	958.14	.18	1	1639.73	.03	2	2417.87	.05
Trt	1	.47	.98	1	45.26	.70	1	319.64	.50
Pretprt*trt	1	226.96	.51	1	102.04	.57	2	661.77	.40
Calving grp	2	275.07	.59	1	48.74	.69	2	507.76	.49
Trt*calving grp	2	134.86	.77	1	16.24	.82	2	78.34	.89
December cs	1	91219.65	<.01	1	125304.29	<.01	1	50817.83	<.01
Error	54	521.82		50	311.97		25	697.13	

TABLE 19. ANALYSIS OF VARIANCE FOR POSTPARTUM COW WEIGHT CHANGES (MARCH-MAY) AND (MAY-AUGUST) IN EXPERIMENT ONE, EXPERIMENT TWO AND EXPERIMENT THREE.

	<u>Experiment 1</u>			<u>Experiment 2</u>			<u>Experiment 3</u>		
		Mean			Mean			Mean	
Source	df	Square	P	df	Square	P	df	Square	P
Mar-May change									
Pretrt	1	1571.71	.02	1	196.37	.42	2	321.80	.28
Trt	1	443.43	.22	1	18758.20	<.01	1	5038.09	<.01
Pretrt*trt	1	11.99	.84	1	324.49	.30	2	161.06	.53
Calving grp	2	832.80	.07	1	38.56	.72	2	184.21	.48
Trt*calving grp	2	21.66	.93	1	768.59	.11	2	49.38	.82
Error	57	292.99		49	295.78		28	244.39	
May-Aug. change									
Pretrt	1	169.83	.48	1	260.30	.32	2	584.95	.23
Trt	1	385.99	.29	1	18016.56	<.01	1	7783.43	<.01
Pretrt*trt	1	306.78	.34	1	19.19	.79	2	554.79	.24
Calving grp	2	612.93	.17	1	237.23	.34	2	345.39	.41
Trt*calving grp	2	555.64	.20	1	349.40	.25	2	199.30	.59
Error	55	332.30		50	255.46		26	373.22	

TABLE 20. OBSERVED VALUES USED IN CHI-SQUARE ANALYSIS OF PERCENT CYCLING PRIOR TO THE BREEDING SEASON, SERVICED IN FIRST 21 DAYS OF BREEDING SEASON AND PERCENT PREGNANT IN EXPERIMENT TWO.

Item	Cycling	Non-cycling	Serviced	Not Serviced	Pregnant	Open
Experiment two:						
RD	97.00	3.00	100.00	0.00	83.00	17.00
UD	100.00	0.00	100.00	0.00	89.00	11.00
P-value		.95		---		.51
Alfalfa	97.00	3.00	100.00	0.00	79.00	21.00
Canola	100.00	0.00	100.00	0.00	93.00	7.00
P-value		.31		---		.13
Alfalfa-RD	93.00	7.00	100.00	0.00	73.00	27.00
Alfalfa-UD	100.00	0.00	100.00	0.00	86.00	14.00
Canola-RD	100.00	0.00	100.00	0.00	93.00	7.00
Canola-UD	100.00	0.00	100.00	0.00	93.00	7.00
P-value		.41		---		.35

TABLE 21. OBSERVED VALUES USED IN CHI-SQUARE ANALYSIS OF PERCENT CYCLING PRIOR TO THE BREEDING SEASON, SERVICED IN FIRST 21 DAYS OF BREEDING SEASON AND PERCENT PREGNANT IN EXPERIMENT THREE.

Item	Cycling	Non-cycling	Serviced	Not Serviced	Pregnant	Open
Experiment three:						
RD	89.00	11.00	79.00	21.00	89.00	11.00
UD	59.00	41.00	71.00	29.00	82.00	18.00
P-value		.03		.56		.54
Alfalfa	67.00	33.00	83.00	17.00	100.00	0.00
Canola	92.00	8.00	85.00	15.00	85.00	15.00
Beet pulp	64.00	36.00	55.00	45.00	73.00	27.00
P-value		.19		.17		.17
Alfalfa-RD	100.00	0.00	100.00	0.00	100.00	0.00
Alfalfa-UD	57.00	43.00	71.00	29.00	100.00	0.00
Canola-RD	100.00	0.00	88.00	12.00	100.00	0.00
Canola-UD	67.00	33.00	83.00	17.00	67.00	33.00
Beet pulp-RD	71.00	29.00	57.00	43.00	71.00	29.00
Beet pulp-UD	50.00	50.00	50.00	50.00	75.00	25.00
P-value		.24		.44		.25

TABLE 22. OBSERVED VALUES USED IN CHI-SQUARE ANALYSIS OF PERCENT SERVICED IN FIRST 21 DAYS OF BREEDING SEASON AND PERCENT PREGNANT IN EXPERIMENT ONE.

Item	<u>Serviced</u>	<u>Not Serviced</u>	<u>Pregnant</u>	<u>Open</u>
Experiment one:				
RD	91.00	9.00	86.00	14.00
UD	100.00	0.00	89.00	11.00
P-value		.11		.67
Alfalfa	97.00	3.00	84.00	16.00
Canola	94.00	6.00	90.00	10.00
P-value		.54		.48
Alfalfa-RD	94.00	6.00	83.00	17.00
Alfalfa-UD	100.00	0.00	85.00	15.00
Canola-RD	93.00	7.00	86.00	14.00
Canola-UD	94.00	6.00	94.00	6.00
P-value		.81		.79

TABLE 23. ANALYSIS OF VARIANCE FOR DAYS TO FIRST ESTRUS IN EXPERIMENT ONE.

<u>Experiment 1</u>			
Source	df	Mean Square	P
Pretrt	1	106.37	.42
Trt	1	740.12	.04
Pretrt*trt	1	43.58	.61
Cowage	6	882.23	<.01
Trt*cowage	6	397.75	.04
Calving grp	2	810.86	.01
Trt*calving grp	2	156.13	.39
Error	44	162.13	

TABLE 24. THE EFFECT OF PREPARTUM PROTEIN SUPPLEMENTATION ON BEEF COW WEIGHT (WT) AND CONDITION SCORE (CS) POSTPARTUM.^a

	<u>Experiment one</u>			<u>Experiment two</u>			<u>Experiment three</u>			
	Alf	Can	SE ^b	Alf	Can	SE ^b	Alf	Can	Cont	SE ^b
May										
wt (kg) ^c	544.6	554.4	4.3	536.0	551.7*	4.4	479.6	493.2	463.3*	5.2
cs ^d	4.1	4.3*	.07	4.0	4.3*	.06	3.9	4.0	3.7*	.09
August										
wt (kg) ^e	574.7	583.0	4.4	575.4	586.2*	3.6	513.6	539.6	514.2*	8.2
cs ^f	4.8	4.8	.07	4.7	4.8	.08	4.6	5.0	4.4*	.12
Change ^g										
wt (kg) ^h	-46.4	-56.7*	3.2	-51.0	-54.9	3.6	-65.6	-60.1	-70.6	4.6
cs	.2	.3	.09	.3	.2	.09	-.1	.2	-.1	.11
Change ⁱ										
wt (kg)	30.7	27.2	3.4	40.2	35.8	3.3	37.0	48.3	51.7	5.9
cs ^j	.7	.5	.08	.7	.6	.09	.7	1.0	.7*	.12

78

^aExperiment one = Late calving cows; Experiment two = Early calving cows; Experiment three = 3 year old cows. Alf = Alfalfa, Can = Canola, Cont = Control supplement; ^bSE = pooled standard error of LSmeans; ^cExperiment two, Alf vs Can, P < .01; Experiment three, Alf vs Can P < .06, Alf vs Cont P < .04, Can vs Cont P < .04; ^dExperiment one Alf vs Can, P < .04; Experiment two, Alf vs Can, P < .008; Experiment three, Alf vs Cont P < .09, Can vs Cont P < .02; ^eExperiment two, Alf vs Can, P < .03; Experiment three, Alf vs Can P < .04, Can vs Cont P < .04; ^fExperiment three, Alf vs Can, P < .04, Can vs Cont, P < .001; ^gChange = change from March to May; ^hExperiment one, Alf vs Can, P < .02; ⁱChange = change from May to Aug. ^jExperiment three, Alf vs Can, P < .05, Can vs Cont, P < .10

MONTANA STATE UNIVERSITY LIBRARIES



3 1762 10130157 8

HOUCHEN
BINDERY LTD
UTICA/OMAHA
NE.