UNIVERSITY OF ALBERTA

THE EFFECTS OF LEVEL OF CONCENTRATE IN POSTWEANING DIET ON RANKING OF BULLS FOR GROWTH RATE, ON REPRODUCTIVE TRAITS AND CARCASS COMPOSITION

BY

P. B. MWANSA

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SUBMITTED BY P. B. MWANSA

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ANIMAL BREEDING AND GENETICS.

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DEDICATED TO MY WIFE EUGENIA

AND

MY TWO DAUGHTERS CHANDA AND MWANSA

Abstract

A total of 224 bull calves from two breed groups were used in two consecutive years to examine the effects of the level of concentrate and change in the level of concentrate on the ranking of bulls for postweaning gain. The effects of concentrate level on reproductive traits, carcass composition and the health status of young bulls were also studied. Within each year the test period of 168 days was divided into two periods separated by a 14 day adjustment period. Within each year and breed group the bulls were randomly assigned to 8 pens (7 bulls/pen). The pens were balanced with respect to age and weight of bulls. Bulls in 4 pens were fed a high concentrate diet (85% grain) ad libitum (H), while those in the other 4 pens were fed a low (L) concentrate diet (half the amount of concentrate fed to H bulls, and hay ad libitum) in the first period. After the adjustment period, the diet of the bulls in 2 of the 4 pens on H was changed to L, while that of the bulls in 2 of the four pens on L was changed to H resulting in four dietary treatment combinations (HH, HL, LH, and LL). Within each breed group the 4 treatments had two replications.

While the rank correlation coefficients in weight gain between the first and second periods were highly significant in the HH (r_s=0.38; p<0.004) and LL (r_s=0.40; p<0.002) treatment groups, those in the LH and HL treatment groups were low and not significantly different from zero. Genetic-nutritional interaction thus seems to exert considerable influence on the ranking of bulls for postweaning gain.

Diet had a positive effect on the size of the scrotum. However, bulls on HH diet had a higher proportion (24.17%) of sperms exhibiting abnormalities compared to bulls on HL, LH and LL diets (15.22%, 17.09% and

16.40%, respectively; $P<0.05$). Therefore, feeding a low concentrate diet in either half of the performance test period might help in reducing the negative effect of high concentrate diet on the reproductive potential of young bulls.

The highest proportion of muscle in the three rib joint was found in the HL treatment group and the lowest in the HH treatment group. Diet is thus an important factor for manipulating carcass composition of beef bulls.

In the second feedlot study (Year 2), all the bulls on high concentrate diet were treated for respiratory infections compared to none on low concentrate. It appeared that feeding high levels of concentrate to bulls in the feedlot predisposes them to respiratory infections.

The results suggested that bulls should be tested for superiority of gain on a low concentrate-high roughage diet in order to minimize the detrimental effects of high concentrate diets on semen characteristics and health status of feedlot bulls.

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CHAPTER 1. GENERAL INTRODUCTION

A. Genotype x environmental interaction in performance testing.

In an attempt to evaluate the relative breeding values of bulls for postweaning rate of growth, the beef industry has designed a number of performance-testing programs.

Performance-testing involves the measurement of traits in live animals and the major advantage of performance testing is that it permits evaluation of the animal at a much earlier age than is possible with progeny testing (Preston and Willis, 1975). This reduces the generation interval, is economical and enables a bull to be used during his most productive years.

There is a lack of uniformity in the management and feeding procedures employed in performance tests (Brown and Arosemena, 1962; Kojer et al., 1962; Jones and Francis, 1963; Crawford et al., 1967, Preston and Willis, 1975). In addition to lack of consistency among testing stations, within station variability is considerable. Traits of economic importance are influenced by the genotype of the individual and environmental factors under which the animal is raised. However, a problem arises when a given set of environmental factors exert different effects upon different genotypes. Selection of breeding stock is then complicated by the need to consider the specific environment wherein the animals and their progeny will be raised. Dempfle and Grundl (1988) pointed out that the phenomenon of genotype x environment interaction makes the definition of the superior animal difficult.

It has been generally accepted that a high nutritional standard provides a better opportunity for the expression of genetic potential, making selection of breeding stocks more accurate compared with the minimal condition (Van Vleck, 1963; Preston and Willis, 1975). In selection experiments, however, the controversy on the optimum nutritional environment to utilize has been going on for over four decades (Hammond, 1947; Falconer and Latyszewski, 1952; Murthy and Taneja, 1982; Bailey and Lawson, 1985). Some workers such as Murthy and Taneja (1982) argued that environmental changes during growth brought different gene arrays into prominence in agreement with Falconer and Latyszewski (1952) but went on to state that the congenial environment was still mandatory for better expression of genetic differences. Similarly, Fowler and Ensminger (1960) from their studies in swine concluded that superiority for rate of gain under full feeding has a different genetic basis (perhaps genes that condition appetite, capacity to consume or digest feed, higher metabolic rate, and/or production of larger amounts of growth hormone) from that of superiority for rate of gain under limited feeding (perhaps genes that condition better feed utilization). Bailey and Lawson (1985) found no significant sire by diet interaction for growth rate and suggested that sires ranked the same for progeny performance on two diets differing in energy levels in agreement with Van Vleck's (1963) report that much of the research results in this area have shown little, if any, genotype x environment interaction in the usual sense (ranking of sire in different environments) but claimed that there is another form of genotype x environment interaction since genetic variability was evidently different from one environmental level to another.

F ior et al. (1977) reported that just as there are genetic differences among types of cattle (breed), genetic differences do exist among cattle of the same type (within breed). For performance testing, therefore, the interaction between genotype and environment (diet) at individual animal level becomes very important with regard to the definition of a superior animal.

B. Plane of nutrition and breed effects on growth parameters

The aim of any system of performance testing must be to evaluate as quickly and as efficiently as possible, genetic differences between animals in terms of their phenotypic expression. Generally, performance testing programs utilize high concentrate diets even though high concentrate diets have been associated with excessive finish (O'Mary and Dyer, 1978), especially in breeds with a high potential for fattening. In addition, bulls fed a high energy (concentrate) diet throughout the test period are generally more susceptible to respiratory diseases (William, 1985) and other feedlot diseases (Perry, 1980).

Berg (1982) reported that breed type and plane of nutrition were important factors influencing the growth of muscle and fat tissue.

Considerable work has been done on studies related to the effects of breed and diet on feedlot characteristics. Woody et al. (1983) studied the effect of various levels of grain in the diet on performance of growing and finishing cattle. They reported that average daily gain increased and feed required per unit of gain decreased as percent grain in the diet increased. Breed x diet interactions have also been the subject of interesting studies. Whereas many studies have shown a breed x nutrition interaction for some feedlot characteristics (Newsome et al., 1985; Bond et al., 1972), others have demonstrated that no such interactions exist (Ferrel et al., 1978).

Generally, it has been accepted that the plane of nutrition affects both the rate and composition of gain (McCarthy, 1985; Bond et al., 1972). With economics of feeding becoming more important as a factor in the overall viability of the beef industry, research attention is shifting more into investigations involving profitable feeding systems. McCarthy (1985) found that the live weight gains were greater for steers fed high than low concentrate diets. Oltjen et al. (1971) reported a feedlot test in which steers fed an all concentrate diet gained faster than steers fed a combination of low and high concentrate diets. Crouse et al. (1985) found that the differences in live weights of Angus and Simmental cattle were greater when the high concentrate diet was fed. Price et al. (1984) suggested that breed and diet were factors that could be manipulated to ensure optimum fat at optimum weight.

C. Plane of nutrition and reproductive parameters

Breeding animals must not only possess the genetic potential for fast gains but must also be reproductively viable. There are many factors affecting reproductive potential in animals. Reproductive traits are not only lowly heritable (Toelle and Robison, 1985) but the problem is further complicated by the fact that in cattle, very low selection intensity can be exerted in female populations (Neely et al., 1982). Bull selection, however can account for 80 to 90% of the total herd improvement over a period of several years (Bogart and Taylor, 1983). In addition, research has shown that selection for some testicular measurements in males has a correlated response in some female reproductive traits. Toelle and Robison (1985) reported that selection for increased testicular size would lead to a decrease in age at first breeding in cattle, had a correlated improvement in female reproductive performance in sheep (Schoeman et al., 1986), and that useful genetic progress would result from it (Purvis et al., 1986). Scrotal circumference is an indirect but effective method for determining the weight of the testis of a live bull. Testicular weight provides an accurate estimate of the sperm-producing parenchyma of the testes of young bulls. Studies in this field have not only revealed the relationship between various testicular measurements (Makarechian et al., 1985) but have also shown their heritabilities (Latimer et al., 1982; Neely et al., 1982). A linear relationship between scrotal circumference and body weight has been reported by different workers in this field (Makarechian et al., 1985; Goonewardene et al., 1988; Madrid et al., 1988).

Relationships between the size of the testis and semen production and semen quality have been the subject of several studies. For example, Madrid et al. (1988) reported a positive correlation between scrotal circumference and epididymal weight and a negative correlation with degree of germinal epithelial loss. They further observed that for every 1 cm increase in scrotal circumference above 32 cm, proximal cytoplasmic droplets and major and minor sperm abnormalities decreased by 8.5% and 2.0%, respectively, along with 13.0% increase in normal sperm cells. In the same year, Swanepoel et al. (1988), working with bulls of the Bonsmara, a synthetic South African beef breed, reported a positive correlation between epididymal sperm reserve and scrotal circumference. Randall (1986) reported that there was considerable variation in scrotal circumference among individuals within breeds. This variation, he suggested, offered cattlemen an opportunity to improve reproduction in beef cattle by selecting individuals within breeds that have above average scrotal circumference.

Information on the effect of level of concentrate in diet on reproductive potential of young beef bulls is quite limited. Whereas some studies like those of Wilsey (1972), Breuer (1980) and Pruitt (1983) have reported larger scrotal circumference in one-year-old bulls fed a high concentrate diet the same workers reported no such effect on semen quality. Results from feeding high and medium energy diets to Angus and Hereford bulls from 6 to 24 months of age reported by Coulter and Kozub (1984) suggested that Hereford bulls were more susceptible to the effects of high energy diets than Angus bulls as evidenced by lowered epididymal sperm reserves in Herefords fed a high energy diet. Feeding of high versus medium energy diets from weaning to 15 months of age has also been reported to result in substantial reductions in sperm reserves in Hereford and Angus bulls (Coulter, 1986). Walker (1967) had reported results alluding to the fact that the level of concentrate in diet had significant effects on semen and testicular measurements confirming earlier reviews by

Hentges (1964) which stressed that feeding high concentrate (high energy) diets to bulls to obtain rapid gains might affect semen quality and ultimately reduce reproductive potential of these bulls.

A superior bull should not only produce good quality semen, but must also exhibit high sex drive. Libido in bulls has been defined as th willingness and eagerness to mount and attempt service, with mating ability described as the ability to complete service (Chenoweth, 1986). The literature is somewhat equivocal about the effect of nutrition on libido (Chenoweth, 1986). Tilton et al. (1964) reported that libido was not affected by the plane of nutrition. On the other hand, Parker and Thwaites (1972) and Mattner and Braden (1975) demonstrated that libido was significantly reduced in rams fed a submaintenance diet and in bulls fed a high concentrate diet for prolonged periods of time (Hentges, 1967).

The effects of low or high concentrate diets and change in the level of concentrate fed at different stages of the postweaning performance test on scrotal circumference, sex drive and semen quality of young beef bulls has not been adequately explored.

D. Plane of nutrition and carcass characteristics

In 1932, Hammond and his co-workers prepared a series of papers from which there emerged principles on growth and development (Palsson, 1955). The major carcass tissues; namely bone, muscle and fat, were found to exhibit different growth patterns. Bone developed earliest, followed by muscle and lastly fat. Fortin et al. (1981) reported that prior to the onset of rapid fattening, the proportion of fat increased slowly, while the proportion of bone decreased and the proportion of muscle increased. They went on to report that during the period of rapid fattening, the proportions of bone and muscle decreased , while the proportion of fat increased rapidly. These basic principles have been verified in cattle (Callow, 1948; Berg and Butterfield, 1968; Butterfield and Johnson, 1971; Murray et al., 1974; Anderson, 1975; Berg et al., 1978). The influence of energy consumption on growth of muscle and fat tissues was summarized by Berg (1982), indicating that, a high energy ration and ad libitum feeding results in earlier fattening, a low energy ration or restricted feeding causes later or delayed fattening and that increased percentage of roughage in a diet, generallv, results in decreased percent of fat in the carcass.

Harrison (1978) argued that fluctuating feed grain prices have generated considerable interest in alternative feeding regimens when weather, export agreements, or other factors make feeding grain to cattle unprofitable. Newsome et al. (1985) further commented that this situation coupled with the fact that consumers want less fat in their meat has challenged animal scientists to develop cattle finishing systems that will benefit the entire industry, as well as the consumer. In addition, greater efficiency of feed conversion and higher edible carcass yields have increased interest in production of meat from bulls.

Studies on the effect of nutrition on carcass characteristics in steers and heifers have been reported in the literature (Ferrel et al., 1978; Harrison, 1978; McCarthy et al., 1985; Waldman, 1971; Bowling et al., 1977; Smith et al., 1977; Oltjen et al.,1971). A few workers have compared carcass characteristics of steers, heifers and bulls (Field, 1971; Fortin et al., 1981) and generally agree that bulls exhibit higher carcass and lean yields compared to steers and heifers.

However, the effect of changing the level of concentrate at different stages of the performance testing period on carcass characteristics has not been adequately exploited in intact male calves.

A series of studies were, therefore, undertaken to examine the significance of individual animal genotype x nutrition interaction for growth potential and the effects of level of concentrate and change in the level in postweaning diet on reproductive traits, carcass composition and the health status of young bulls.

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CHAPTER 2. THE EFFECT OF CHANGE IN POSTWEANING LEVEL OF CONCENTRATE ON THE RANKING OF YOUNG BULLS FOR GROWTH RATE[1]

A. INTRODUCTION

Traditionally, performance-testing programs are applied by the beef industry to evaluate the relative breeding values of bulls for postweaning rate of growth.

It has been suggested that a high nutritional standard provides a better opportunity for the expression of genetic potential for growth rate, making selection among breeding stocks more accurate compared with a minimal nutritional condition (Van Vleck, 1963). However, performance-testing under high plane of nutrition has had its accompanying side effects. Overfeeding may lead to excessive finish (O'Mary and Dyer, 1978) especially in breeds with a high potential for fattening (Price et al., 1984). In addition, bulls fed a high concentrate diet throughout the test period are generally more susceptible to respiratory diseases (William, 1985) and other feedlot diseases (Perry, 1980).

In selection experiments, the controversy on the optimum nutritional environment has been going on for over four decades, (Hammond ,1947; Falconer and Latyszewski, 1952; Murthy and Taneja, 1982 and Bailey and Lawson ,1985). Some workers such as Murthy and Taneja (1982) argued that environmental changes during the growth period brought different gene arrays into prominence (in agreement with Falconer and Latyszewski, 1952)

[1]A version of this chapter has been submitted for publication. Mwansa, P. B. and M. Makarechian. Journal of Animal Science.

but went on to state that a congenial environment was still mandatory for better expression of genetic differences.

So far, many studies on the subject have been done utilizing various genotypes and various nutritional regimens in fixed times and/or constant end points. However, the effect of change in the level of concentrate in feedlot on ranking of young bulls for growth rate at different stages of the performance-test period has not been adequately examined in evaluating the significance of the interaction between an animal's genotype and the nutritional environments. This experiment was, therefore, set up to study the effect of change in the level of concentrate during the postweaning performance-test period on the ranking of young bulls for growth potential.

B. MATERIALS AND METHODS

Experimental design

Two postweaning performance tests were carried out in 1988 and 1989 at the University of Alberta ranch at Kinsella, Alberta using bulls from two synthetic breed groups. In each year and within each breed group, 56 weaned bull calves were randomly allocated to 8 subgroups (pens) with the restriction that the subgroups were approximately balanced with respect to age and weight.

The total performance-test period after the initial adjustment period of 21 days was 168 days which was divided into two equal periods of 77 days with a 14-day adjustment period in between. During the 21 day warm up period all the calves were fed on average 5 kg of long hay per head per day for the first 10 days. They also had unlimited access to bedding straw. On the 11^{th} day the calves were fed on average 1/2 kg of concentrate and 3 kg of hay per head per day. The amount of hay was gradually reduced and that of grain increased until on the last day of warm up the calves were each receiving 4 kg of concentrate and 1/2 kg of hay per day. During the first period, half of the pens within each breed group received a high concentrate diet (H) while the rest of the pens received hay ad libitum and half as much concentrate as the animals on high concentrate (L). The methods used in the analysis of feeds and the composition of hay, concentrate and premix supplements are given in Appendices 1 and 2 (pages 85, 87). After the mid-period adjustment of 14 days, diets of animals in half of the pens within each breed group were changed from L to H and vice versa resulting in some modification of a reversal or switchback design described by Brant (1938) and further explained by Taylor and Armstrong (1953), giving treatment combinations of HH, high concentrate in both periods of the test; HL, high concentrate in the first shifted to low concentrate in the second period of the test; LH, low concentrate and shifted to high concentrate in the second period of the test; and LL, low concentrate in both periods of the test. In each year the 4 treatments had two replications within each breed group (see Appendix 3 for schematic design of the experiment, page 88).

Animals

In each year, a sample of 112 bull calves were used for the experiment. The calves belonged to two synthetic breed groups namely Beef Synthetic #1 (SY1) and Beef Synthetic #2 (SY2) and were on average 192±5 days old and weighed 236±6 kg at the start of the test. A description of breeding, selection and management practices of the herds has been given by Berg et al. (1990). Briefly, SY1 is mainly a composite of 31% Charolais, 36% Angus and 21% Galloway and SY2 is mainly a composite of 60% Hereford, 12% Angus, 8% Charolais and 5% each of Galloway and Brown swiss (see Appendix 4 for complete breed composition since 1962, page 89). The SY2 was derived from a group formerly referred to as Hereford Crossbred (Berg et al. 1986).

Measurements

In the first year, bulls were weighed at the beginning and end of each period along with height measurement at the hip (HHT). In the second year bulls were measured for weight and height at the hip at 28-day intervals. Backfat thickness (BFAT) was ultrasonically measured using a Scanogram[2] between the 12 and 13^{th} rib on the right side after the completion of the entire test period on all the bulls in the first year and at 28-day intervals in the second year on randomly pre-selected 3 or 4 bulls from each pen. Average daily gain (ADG) in the first, second and the entire test period was calculated for each animal. The intake of

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[2]Model 722, Ithaco, Ithaca, NY

concentrate and hay on a pen basis was also recorded on a weekly basis.

Rank correlation analysis

The Spearman option of the correlation procedure of Statistical Analysis System (SAS, 1985) was first used to estimate correlation coefficients for ADG ranking between the first and second periods within year-breed group-diet subclasses. Year and breed group were excluded from the final analysis after the preliminary analysis indicated that they did not affect (P>0.05) the correlation estimates, leaving diet as the only blocking factor(see Appendix 5 for formula and computational method of SAS rank correlation procedure, page 90). The data was therefore, pooled across year and breed group for the rank correlation analysis in order to examine the magnitude of reshuffling in the ranking of bulls for growth rate that might occur when diets were changed during postweaning performance-testing and to examine the possibility of reducing the length of the performance-test period from 168 days to 77 days.

Covariance analysis.

In a preliminary analysis a fixed model including year, breed group and diet was fitted to the data as main effects. Year was found to be a non significant factor (P>0.05) and therefore, was excluded from the final analysis. Only two-way interactions were considered in the model. The data were analyzed by the Statistical Analysis System (SAS) GLM procedure under model type III with start of test weight and start of test age as covariates. Dependent variables were average daily gain in the first period, average daily gain in the second period, average daily gain during the entire test period, hip height at the end of the test period, backfat thickness at the end of the test period, and feed efficiency in the first, second and entire test period calculated as total digestible energy consumed during a given period divided by total weight gain in that period. An extended version of Tukey's procedure (Steel and Torrie, 1980) was used for mean comparison whenever a significant F ($P<0.05$) test was found.

C. RESULTS AND DISCUSSION

Correlation coefficients

The Spearman's rank correlation coefficients for daily gain in the first and second period within dietary regimens are presented in table 2.1. All the correlations were positive but only those for HH and LL treatments were highly significant ($P<0.004$). The results suggest that bulls may change their rank order for postweaning gain during performance-testing with a change in diet. Bulls whose diets were switched (HL and LH) had insignificant rank correlation coefficients, suggesting that the shift in rank order as a result of change in diet was unpredictable. This was most likely due to the individual animal differences in their capacity to compensate (Dalton and Morris, 1978) and adjust to a low concentrate diet. Even though some unidentifiable environmental factors might have contributed to these correlation estimates, it would be safe to say that these results suggest an interaction between diet and individual animal genotype for growth rate since the rankings of bulls for postweaning gain in different nutritional environments were not correlated.

Apparently different sets of genes conditioned growth response of bull calves to the different nutritional environments (Hanset et al., 1987). The results indicate that selection for postweaning gain in one environment may not be effective in improving the trait if the progeny are to be raised under a different nutritional environment.

Swiger (1961) reported high bimonthly genetic correlations for periodic gains in calves fed the same diet during a 140-day performance test. He concluded that the same genes were largely responsible for gains made during the period of the study. In a switch-over study Mckay et al. (1986) investigating genotype x environmental interaction in mice and utilizing three dietary regimens, reported a consistent trend whereby the largest mice within each diet were those from the same diet in which selection was practised. Results reported here are generally in support of others' (Dempfle and Grundl, 1988; Falconer and Latyszewski, 1952) in emphasizing that an individual animal's superiority for rate of growth may be environment specific. The results support the recommendation by Preston and Willis (1975) that in the presence of genotype-nutritional interaction, prospective herd sires should be evaluated under the same nutritional environment in which their progeny are expected to perform. The results confirm the hypothesis that superiority for rate of gain under full feeding might have a different genetic basis from that on limited feeding (Fowler and Ensminger, 1960).

The part-whole correlation coefficients (Table 2.2) for daily gain between the first period (0-77 days) and the total study (0-168 days) were high and significant for the bulls on HH, HL and LL (0.83, 0.84 and 0.80, respectively). The rank correlation in the LH treatment was medium (0.53) but significant. The correlations reported in this study were lower than those reported by Bailey et al. (1988). Ronchieto (1988) also reported high part-whole correlation coefficient for postweaning growth in cattle.

The lower correlation coefficients estimated in this study may have been partially due to the fact that the period between the two weighings was much longer in the present study compared to those in the cited reports. Therefore, reducing the test period from 168 to 77 days would reduce the accuracy of the test and can not be recommended.

Effect of breed group

Adjusted least squares means of the two breed groups for the growth parameters during the test period are presented in Table 2.3. Age and weight at the start of the test were significant (P<0.05) sources of variation for most of the traits studied indicating the importance of adjusting for both age and weight at the start of the test for unbiased comparisons for feedlot characteristics at the end of the performance test. Breed group x diet interactions were not significant for the traits studied, an observation similar to that reported by Price et al. (1984) using the same herds. Breed group significantly affected most of the traits studied except for backfat. SY1 gained more per day than SY2 during both periods of the performance test (P<0.001). However, the feed efficiency was similar at the end of the test period in both breed groups, suggesting that the higher gains in SY1 bulls were accompanied by increased energy consumption. These observations differed with those reported by McCarthy et al. (1985) who found that large framed steers tended to have higher average daily gains compared to small framed steers. The ratio of backfat thickness to body weight was significantly affected by breed group, with SY2 having more subcutaneous fat per unit of body weight ($P<0.01$) than SY1. SY2 was taller ($P<0.001$) than SY1 at the end of the performance-test period.

Effect of Diet

Diet significantly ($P<0.05$) affected most of the traits studied (Table 2.4). During the first period, bulls on L (LL and LH) gained less than bulls on H (HH and HL) as expected. During the second period, bulls on the LH had the maximum ADG as expected followed by those on HH, HL and LL, respectively, with HL and LL having similar gains ($P<0.05$). Bulls on the same diet during the total test period had comparable ADG in the first and second periods as expected although those on HH gained slightly less and those on LL gained slightly more in the second period compared with the first period. These differences were, however, not statistically significant ($P>0.05$). The trend of gain observed in bulls on HH during the two periods is in agreement with the report by Oltjen et al. (1971) for steers fed an all-concentrate diet in both periods. On the other hand, ADG in HL bulls was approximately 34% less and in LH bulls was approximately

76% more during the last 77 days of the test compared with gain in the first period.

Differences in feed efficiency calculated on pen basis were generally in favour of bulls on a high concentrate diet during the first period of the test. In the second period of the test, the differences were less clear. For the total study, dietary-induced differences in feed efficiency were not significant (P>0.05). This is in disagreement with a report by Woody et al. (1983) who reported that steers on high grain diet were 16% more efficient than those on low grain diet. The results are, however, similar to those reported by McCarthy et al. (1985) who found no difference in feed efficiency in steers fed diets differing in grain content.

Bulls on HH and LH diets had comparable values for backfat thickness at the termination of the feedlot test and so did the bulls on HL and LL diets (P<0.05). A similar trend was observed for the ratio of backfat to final body weight. Bulls on HH and LH diets had significantly more subcutaneous fat than those on HL and LL. In general, the results indicated that even though bulls fed a high concentrate diet at least in the last 77 days of the test had higher weight gains and had accumulated more subcutaneous fat, no significant (P>0.05) differences in feed efficiency were observed. Diet had significant (P<0.05) effect on hip height.

There was a striking similarity between the growth patterns of body weight and backfat thickness within dietary regimens during the performance test period (Figure 2.1). Bulls on HL and LH reversed and switched their rate of weight gain and backfat thickness at approximately the same time (at about 1 month after diets were switched), indicating that there was a close relationship between body weight gain on test and subcutaneous fat deposition. Ferrel et al. (1978) also reported that high weight gain on test on high concentrate diet was accompanied by fat accumulation.

Table 2.1. Spearman's rank correlation coefficients for ADG between the first (day 0-77) and second (day 91-168) periods of the test within dietary regimens.

Diet	n	Rank correlations (r_s)	Level of Significance
HH	54	0.38	0.004
HL	55	0.23	0.10
LH	56	0.12	0.37
LL	56	0.40	0.002

Table 2.2. Spearman's correlation coefficients between ADG in the first period (day 0-77) and ADG for the total study (day 0-168) within dietary regimens.

Dietary regimens	n	Rank correlation	Level of Significance
HH	54	0.83	0.0001
HL	54	0.84	0.0001
LH	56	0.53	0.0001
LL	56	0.80	0.0001

Table 2.3. Adjusted least squares means for the feedlot performance of bulls by breed group, period and for the total study.

Item	SY1	SY2
No. of bulls	111	110
Period 1 (day 0-77):		
ADG, $kg.d^{-1}$	1.5±0.02	1.3±0.02***
Feed Efficiency[1]	70.0±1.4	75.6±1.4*
Period 2 (day 91-168):		
ADG, $kg.d^{-1}$	1.6±0.02	1.4±0.02***
Feed Efficiency	89.4±3.3	93.1±3.3
Total study (day 0-168):		
ADG, $kg.d^{-1}$	1.6±0.02	1.4±0.02***
Feed Efficiency	79.5±1.8	84.2±1.8
Backfat thickness, mm	6.9±+0.3	7.5±0.3
Hip height, cm	187.3±0.5	190.6±0.5***
Backfat/Body weight, $mm.kg^{-1}$	0.014±0.001	0.016±0.001**

[1]Digestible Energy (MJ).kg^{-1} gain.

*, **, ****.Breed group differences significant at $P<0.05$, $P<0.01$ and $P<0.001$, respectively.

Table 2.4. Adjusted least squares means for the feedlot performance of bulls by dietary regimens, period and for the total study.

Item	HH	HL	LH	LL
no. of bulls	54	54	56	56
Period 1 (day 0-77):				
ADG, $kg.d^{-1}$	1.8±0.03[a]	1.8±0.03[a]	1.2±0.03[b]	1.2±0.03[b]
Feed Efficiency[1]	68.8±2.0[b]	69.3±2.0[b]	78.5±2.0[a]	74.7±2.0[a]
Transition	none	H---L	L---H	none
Period 2 (day 91-168):				
ADG, $kg.d^{-1}$	1.7±0.03[a]	1.2±0.03[b]	2.0±0.03[c]	1.2±0.03[b]
Feed Efficiency	90.1±4.7[ab]	101.8±4.7[a]	75.9±4.7[b]	97.2±4.7[a]
Total study (day 0-168):				
ADG, $kg.d^{-1}$	1.8±0.02[a]	1.4±0.02[c]	1.6±0.02[b]	1.2±0.02[d]
Feed Efficiency	80.0±2.5	83.8±2.5	76.8±2.6	86.8±2.6
BFAT, mm	9.2±0.4[a]	5.8±0.4[b]	9.3±0.4[a]	4.5±0.4[b]
HHT, cm	187.5±0.7[b]	188.8±0.7[ab]	189.2±0.7[ab]	190.2±0.7[a]

[a,b,c,d]Means in rows having the same letter do not differ significantly at $P<0.05$.

[1]Digestible Energy (MJ).kg^{-1} gain.

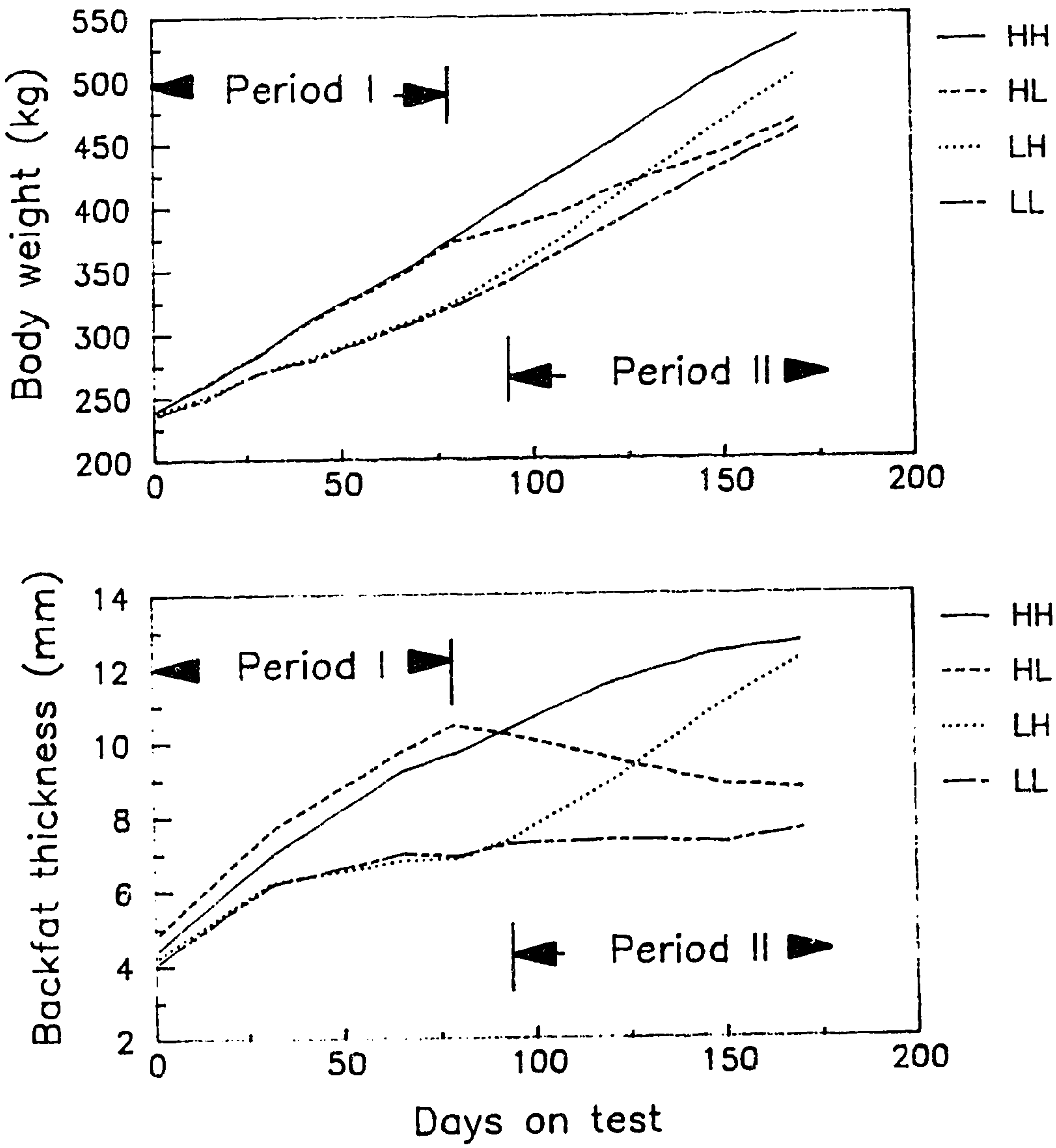

Figure 2.1. Comparison of growth pattern of body weight and backfat thickness within dietary regimens during the performance-test period.

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CHAPTER 3. THE EFFECTS OF POSTWEANING LEVEL OF CONCENTRATE FEEDING ON SCROTAL CIRCUMFERENCE, SEX DRIVE AND SEMEN QUALITY OF YOUNG BEEF BULLS[3]

A. INTRODUCTION

Information on the effect of plane of nutrition during a feedlot test period on the reproductive capacity of young beef bulls is limited. Researchers like Wilsey (1972), Breuer (1980) and Pruitt (1983) have reported that a high plane of nutrition provided to yearling bulls increased scrotal circumference while it had negative effects on semen quality. Feeding of high versus medium energy diets from weaning to 15 months of age has also been reported to result in substantial reductions in sperm reserves in Herefords and Angus bulls (Coulter, 1986). Feeding of high versus medium energy diets for a slightly longer period (from 6 to 24 months of age) has been reported to result in substantial reductions in sperm reserves in Hereford and Angus bulls (Coulter and Kozub, 1984).

Although high plane of nutrition has been reported to have favourable effects on the expression of genetic potential for growth rate in young bulls (Gillespie, 1983), on growth and carcass characteristics (Woody et al., 1987) and on feed efficiency (Price et al., 1984), it has also been reported to reduce the reproductive potential of young bulls (Walker, 1967; Hentges, 1967; Ensminger, 1976; Church, 1984).

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[3]A version of this chapter has been submitted for publication. Mwansa, P. B. and M. Makarechian. Journal of Theriogenology.

The literature is somewhat equivocal about the effect of nutritional level on libido (Chenoweth, 1986). Tilton et al. (1964) reported that the plane of nutrition did not affect libido, while on the other hand, others (Parker and Thwaites, 1972; Mattner and Branden, 1975) demonstrated that libido was significantly reduced in rams fed a submaintenance diet and was reduced in bulls fed high concentrate diets for prolonged periods of time (Hentges, 1967).

The effect of change in the level of concentrate feeding at different stages of the postweaning performance test on scrotal circumference, sex drive and semen quality of young beef bulls has not been fully examined. This study was therefore conducted to examine the effects of high or low concentrate diets and the changing of diets during the testing period on scrotal circumference, semen quality and sex drive of young beef bulls.

B. MATERIALS AND METHODS

Experimental design

The design of the experiment, dietary treatments and the management were as described in chapter 2 (page 19). All bulls were put on a high concentrate diet after the 168 d test for finishing. Only the SY1 breed group was used in this study as SY2 breed group was used for carcass evaluation.

Scrotal circumference was measured at the widest portion with testes fully descended in the scrotal sac with a Lane[4] scrotal tape and backfat was measured ultrasonically between the 12th and the 13th rib on the right side of the animal with a scanogram[5] at the end of the test period in the first year and at 28-day intervals during the test period in the second year on randomly pre-selected 4 or 3 bulls from each pen to a total of 106 bulls.

Libido in bulls has been defined as the willingness and eagerness to mount and attempt service, with mating ability described as the ability to complete service (Chenoweth, 1986). In the first year, the bulls were tested for libido only once (at the age of 12 months), a month after the completion of the performance test. In the second year bulls were tested for libido twice, at one month and at three months after the completion of the performance test (at the age of 12 and 14 months, respectively).

Three oestrus-induced cows were restrained in service crates approximately five meters apart in a yard. Five bulls at a time were allowed in the yard for 15 minutes in each test.

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[4]Lane manufacturing inc., Denver, Colorado

[5]Model 722, Ithaco, Ithaca, NY

The bulls were scored for sexual **INTEREST**, frequencies of **MOUNTS** and **SERVICES**. A total **LIBIDO** score on a 0 to 10 basis (Chenoweth, 1986) was calculated as follows:

0 = Bull showed no sexual interest

1 = Sexual interest shown only once

2 = Positive sexual interest on more than one occasion

3 = Positive sexual interest on more than three occasions

4 = One mount or mounting attempt without service

5 = Two mounts or mounting attempts without service

6 = More than two mounts or mounting attempts without service

7 = One service followed by no further sexual interest

8 = One service followed by sexual interest including mounts or mounting attempts.

9 = Two services followed by no further sexual interest

10 = Two services followed by sexual interest including mounts, mounting attempts or further service.

Seminal characteristics were evaluated only in the second year of study by a skilled veterinarian. Semen samples were collected at two weeks and at two and half months after the completion of the performance test (at the age of 11.5 and 13.5 months, respectively) by electroejaculation.

Techniques used to fix aliqouts of raw semen for morphological examination and methods used in the analysis of semen traits were those reported by Johnson et al. (1976) and Crowe-Swords and Taylor (1979). Briefly, from each ejaculate, several drops of semen were fixed in 2 ml of buffered formol-saline solution, and the resultant specimens were refrigerated at 4°C until morphological examination of a wet mount by use of phase contrast microscopy. Two hundred sperms were counted and were classified according to Randall (1986) criterion thus: **major sperm abnormalities** (proximal cytoplasmic droplets, pyriform heads, coiled or folded tails, tails coiled around the head, midpiece defects, maldevelopment, double forms and craters) and **minor sperm abnormalities** (distal cytoplasmic droplets, tailless normal heads, bent or terminally coiled tails, narrow, small, giant, or short-broad heads and abnormal acrosomes). Percent total sperm abnormality was calculated as a sum of major and minor sperm abnormalities.

Two analyses of the data were used with components of libido score used as dependent variables. In the first analysis, a fixed model including year and diet as the main effects was fitted to the combined (year 1 and year 2) data set. In the second analysis a fixed model including age of bull and diet as the main effects was fitted to the second year data. Age of bull and diet were the main effects when semen characteristics were considered as dependent variables. The data were analyzed by the Statistical Analysis System (SAS, 1985) GLM procedure under model type III. In the analysis of libido, dependent variables were number of times a bull showed sexual interest, number of mounts, number of services and total libido score. In the analysis of semen quality, dependent variables were scrotal circumference, percent total progressive sperm motility, percent major sperm abnormalities, percent minor sperm abnormalities and percent total sperm abnormalities. The extended version of Tukey's procedure (Steel and Torrie, 1980) was used for mean separation whenever a significant ($P<0.05$) F test was found. The correlation procedure of SAS was used to determine correlations among the above variables within diet and age subclasses.

C. RESULTS AND DISCUSSION

Libido

Effect of year

Except for number of services, year was a significant source of variation for all the components of libido score at the same age (Table 3.1). In the second year the bulls exhibited more interest, and had higher number of mounts and total libido scores than in the first year ($P<0.001$).

This could be a reflection of the differences in the intangible environmental conditions between the two years even though libido was assessed when average temperatures ranged between 10 and 15°C for both years and bulls in this study were evaluated for libido and semen characteristics during the same season.

Effect of age

Age of bull was a significant source of variation for libido score (Table 3.2). Differences due to age of bull were observed to be significant for number of times a bull showed sexual interest and libido score (P<0.001 and P<0.05, respectively) but not for number of mounts and services achieved by the bull (P>0.05). Bulls showed more (P<0.001) interest in females and had higher (P<0.05) libido score at 14 months compared to 12 months of age. This difference may have been partially due to the bulls' previous sexual experience at 12 months. It was not possible to separate the effect of age from that of bulls' previous sexual experience in this study.

Effect of diet

Diet had no significant (P>0.05) influence on any of the components of libido scores. The results are contrary to the results reported by Alkass and Bryant (1984) in which rams were fed a high or low concentrate diet. They reported a significant effect of diet on libido measured by the number of mounts per ejaculation, the reaction time to first mount and reaction time to first ejaculate in favour of the high. The difference in the evaluation of libido and the species used might have partially contributed to the difference with these results. Walker (1967) reported results of an experiment in young bulls whose libido was significantly depressed by feeding a high concentrate diet for a prolonged period of time. The length of time during which the animals were on high concentrate was 2 to 3 years and might have contributed to the difference with the results reported in this study.

Semen characteristics

Effect of age

The effects of age of bull on scrotal circumference and semen quality are shown in Table 3.3. Age of bulls was a significant source of variation for scrotal circumference ($P<0.001$), total progressive sperm motility ($P<0.01$) and percent major sperm abnormalities ($P<0.05$). Bulls had larger scrotal circumference, higher percent progressive motility and lower percent major sperm abnormalities at 13.5 compared to 11.5 mo of age.

Total progressive sperm motility was increased by approximately 10%; major sperm abnormalities were reduced by approximately 3% and total sperm abnormalities were reduced by approximately 2% with two months increase in age. These results are generally in agreement with another report (Almquist et al., 1976) in which significant increases in sperm motility, scrotal circumference and ejaculate volume were observed with increase in age. However, percent minor sperm abnormalities remained almost constant from 11.5 to 13.5 months of age in this study.

Effect of diet

Diet-induced differences in the proportion of sperm exhibiting progressive motility were not observed (Table 3.4). This is in agreement with other reports (Wilsey, 1972; Breuer, 1980; Pruitt, ;1983) in which no effect of energy intake from weaning to 1 year of age on progressive motility was observed. However, it differs with the results of another report (Coulter and Kozub, 1984) in which very poor progressive sperm motility was observed in Hereford bulls fed a diet high in energy compared to a diet medium in energy.

Scrotal circumference, percent minor, percent major and percent total sperm abnormalities were significantly affected by diet ($P<0.05$; Table 3.4). Bulls fed HH diet had significantly larger scrotal circumference, higher percent major, minor and total sperm abnormalities compared to bulls fed HL, LH and LL diets. There was no significant ($P>0.05$) difference in semen quality between bulls fed HL, LH and LL diets. These results are generally in agreement with those of Hentges (1967), Breuer (1980) and Pruitt (1983). The results suggest that feeding bulls a high concentrate diet for the entire performance test period might result in reduced semen quality, whereas feeding a low concentrate-high roughage diet during the entire test period or in either half (first or last 77 days) of the performance test period would not lower the semen quality and might help in preventing the detrimental effects of prolonged high concentrate diets on semen quality. The results indicate that in general high concentrate diet would increase scrotal circumference and prolonged feeding of high concentrate diet might have negative effect on the quality of semen. Coulter (1986) reported that feeding of high concentrate diets might cause substantial harm to the reproductive potential of young bulls. Speculations that the excess deposition of scrotal fat in over-conditioned bulls might be a serious contributing factor have been reported (Walker, 1967).

There seemed to be some association between the increase in scrotal circumference and backfat thickness within each diet during the performance test period (Figure 3.1). It is interesting to note that whereas the HL and LH bulls reversed and switched their rate of accumulation of backfat thickness at about the 125 d on test (approx. 1 mo. into period 2), they reversed and switched their scrotal growth rate approximately 3 weeks later (150 d on test). This indicates that dietary energy manipulation would result in a faster response in backfat thickness than that in scrotal circumference. It also confirms that scrotal circumference is partially affected by the rate of fat deposition in the bull.

Correlations

Most of the correlation coefficients between seminal characteristics were low (Table 3.5 and Table 3.6) and nonsignificant (P>0.05) within age and dietary regimens. There was a significant (P<0.001) correlation between scrotal circumference and percent minor and total sperm abnormalities in eleven and half-month-old bulls raised on LH diet (Table 3.5). Scrotal circumference was also found to be significantly (P<0.05) correlated with percent sperm motility in thirteen and half-month-old bulls raised on the same diet (Table 3.6). These results show that there is a positive association between a bull's scrotal circumference and poor semen quality when raised on a LH dietary regimen. This is in partial agreement with Madrid et al. (1988) who reported linear relationship between scrotal circumference and major and minor sperm abnormalities. Percent minor sperm abnormalities showed low correlation (P>0.05) with percent major sperm abnormalities within age and dietary regimen. There was no significant (P<0.05) relationship between total progressive motility with either scrotal circumference or semen quality as judged by major and minor sperm abnormalities within age and dietary regimens. At both ages and within each dietary regimen (Table 3.5 and Table 3.6), percent minor and percent major sperm abnormalities were both highly (P<0.01) correlated to percent total sperm abnormalities, since these were part-whole correlations. In general, these results indicated that a bull's scrotal circumference would not be a good indicator of his semen quality but that various measurements of sperm abnormalities were significantly related to total sperm abnormalities regardless of age and dietary regimen.

Table 3.1. Mean scores for components of libido score during the first and second year at the same age (12 months).

Item	Year 1	Year 2
No. of bulls	57	54
Age, days	365±1.1	357±1.1
Body weight, kg	463±4.0	466±4.0
No. of times bull showed		
sexual interest	2.3±0.2	3.6±0.2***
No. of mount	3.4±0.4	5.6±0.4***
No. of services	0.4±0.1	0.5±0.1
Libido score	5.1±0.3	6.6±0.3***

*, **, ***Year differences significant at $P<0.05$, $P<0.01$ and $P<0.001$, respectively.

Table 3.2. Least squares means for the effect of age on components of libido and libido scores.

Item	Age of bulls: 12 months	14 months
No. of bulls	54	54
No. of times bull showed sexual interest	3.6±0.1	4.4±0.1***
No. of mounts	5.6±0.3	5.4±0.3
No. of services	0.5±0.1	0.7±0.1
Libido score	6.6±0.2	7.3±0.2*

*, **, ***Age differences significant at $P<0.05$, $P<0.01$ and $P<0.001$, respectively.

Table 3.3. Least squares means for the effect of age on scrotal circumference and semen quality of bulls.

Item	Age of bulls 11.5 months	13.5 months
No. of bulls	45	45
Scrotal circumference, cm	35.6±0.4	37.6±0.4***
Sperm motility, %	44.6±2.4	54.6±2.3**
Sperm abnormalities:		
Major, %	10.7±0.9	7.9±0.8*
Minor, %	9.2±0.9	9.6±0.9
Total, %	19.0±0.4	17.4±0.5

*, **, ***Age differences significant at P<0.05, P<0.01 and P<0.001, respectively.

Table 3.4. Least squares means for the effects of diet on scrotal circumference and semen quality of young beef bulls.

Item	HH	HL	LH	LL
No. of bulls	11	12	13	10
Scrotal				
circumference, cm	38.3±0.5[a]	36.4±0.5[b]	36.4±0.5[b]	35.2±0.5[b]
Sperm motility, %	45.5±3.45	53.4±3.2	47.9±3.2	51.5±3.5
Sperm abnormalities:				
Major, %	12.5±1.2[a]	8.7±1.1[b]	7.7±1.1[b]	8.3±1.3[b]
Minor, %	13.4±1.3[a]	6.6±1.2[b]	9.3±1.2[b]	8.1±1.3[b]
Total, %	24.2±2.1[a]	15.2±1.9[b]	17.1±1.9[b]	16.4±2.1[b]

[a,b]Means in rows having the same letter do not differ significantly at $P<0.05$.

Table 3.5. Relationships between scrotal circumference and semen characteristics in eleven and half-month-old bulls within dietary regimens.

	Sperm motility, %	Sperm abnormalities minor, %	Sperm abnormalities major, %	Sperm abnormalities total, %
HH Dietary regimen				
Scrotal circumference, cm	0.16	-0.01	-0.23	-0.14
Sperm motility, %		0.16	-0.45	-0.16
Sperm abnormalities:				
minor, %			0.26	0.82***
major, %				0.76***
HL Dietary regimen				
Scrotal circumference, cm	0.07	0.02	-0.01	0.01
Sperm motility, %		-0.38	-0.21	-0.30
Sperm abnormalities:				
minor, %			0.65*	0.86***
major, %				0.94***
LH Dietary regimen				
Scrotal circumference, cm	0.08	0.75**	0.46	0.71**
Sperm motility, %		-0.04	0.18	0.08
Sperm abnormalities:				
minor, %			0.45	0.86***
major, %				0.84***
LL Dietary regimen				
Scrotal circumference, cm	0.14	-0.19	0.04	-0.14
Sperm motility, %		-0.16	0.08	-0.08
Sperm abnormalities:				
minor, %			-0.30	0.66*
major, %				0.52

*, **, ***Significant at $p<0.05$, 0.01 and 0.001, respectively.

Table 3.6. Relationships between scrotal circumference and semen characteristics in thirteen and half-month-old bulls within dietary regimens.

	Sperm motility, %	Sperm abnormalities minor, %	major, %	total, %
		HH Dietary regimen		
Scrotal circumference, cm	-0.55	-0.06	0.36	0.21
Sperm motility, %		-0.06	0.32	0.18
Sperm abnormalities:				
minor, %			-0.04	0.70**
major, %				0.68**
		HL Dietary regimen		
Scrotal circumference, cm	0.36	0.23	0.14	0.20
Sperm motility, %		-0.07	-0.34	-0.28
Sperm abnormalities:				
minor, %			0.45	0.78***
major, %				0.91***
		LH Dietary regimen		
Scrotal circumference, cm	0.54*	0.17	0.27	0.23
Sperm motility, %		0.04	0.08	0.06
Sperm abnormalities:				
minor, %			0.45	0.95***
major, %				0.72***
		LL Dietary regimens		
Scrotal circumference, cm	0.05	-0.06	0.22	0.11
Sperm motility, %		-0.03	0.48	0.30
Sperm abnormalities:				
minor, %			0.55	0.84**
major, %				0.92***

*, **, ***Significant at $p<0.05$, 0.01 and 0.001, respectively.

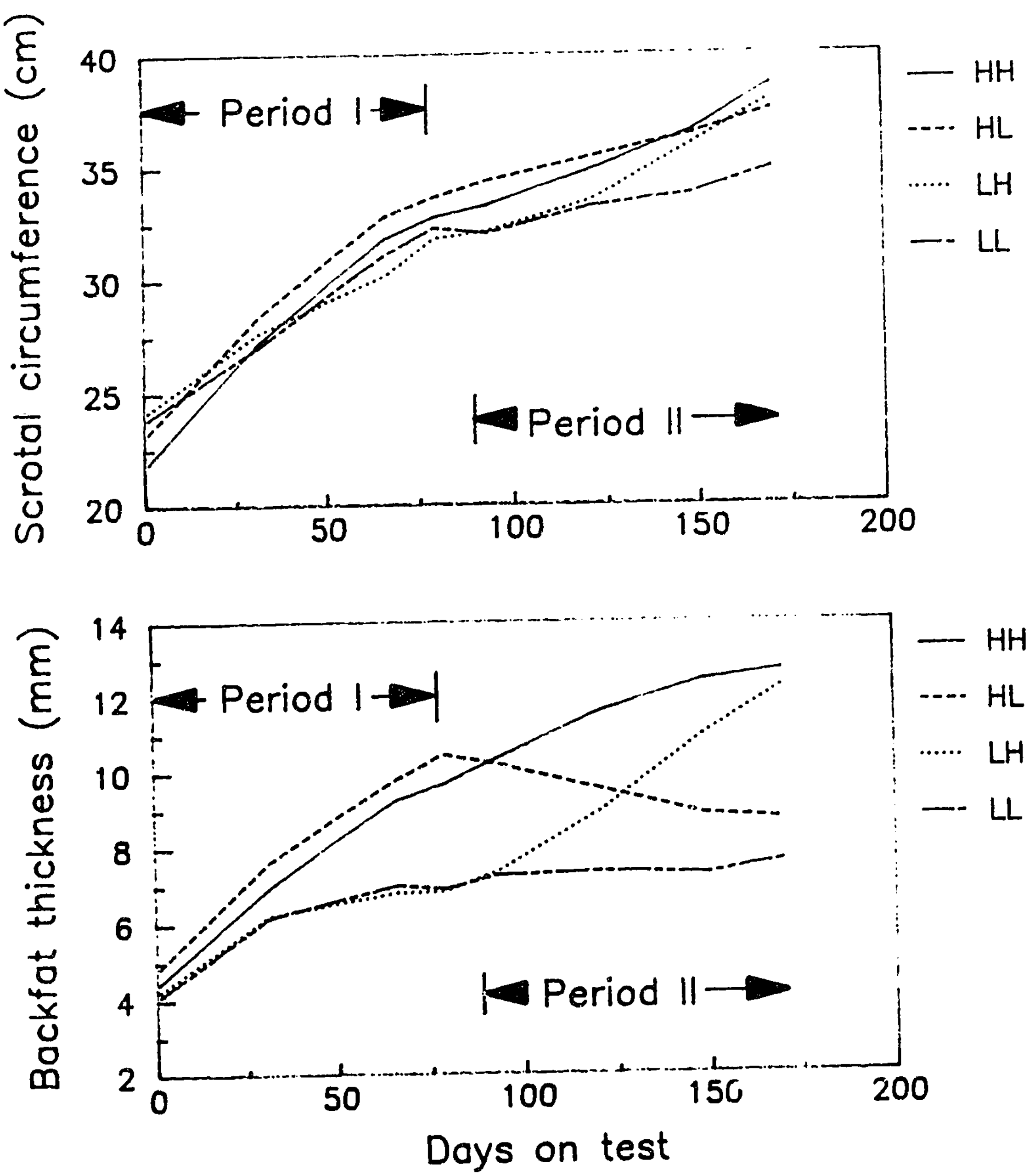

Figure 3.1. Comparison of growth pattern of scrotal circumference and backfat thickness of bulls within dietary regimens during the performance–test period.

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CHAPTER 4. THE EFFECT OF CHANGE IN POSTWEANING LEVEL OF CONCENTRATE ON CARCASS CHARACTERISTICS OF BEEF BULLS

A. INTRODUCTION

In recent years, there has been an increased interest in meat production from intact males influenced by a declining demand for animal fat, increased emphasis on efficient red meat production, and the need for greater amounts of animal protein for our ever increasing world population (Field, 1971).

In an attempt to reduce feed costs of red meat production, studies on the appropriate nutritional regimen have been conducted (Newsome et al., 1985; Price et al., 1984; George et al., 1976) mainly with steers and Heifers. Studies involving intact male calves have demonstrated that meat carcasses from intact male calves are leaner than those from castrates (Field, 1971). Generally, it has been shown that the level of energy in the diet influences carcass composition (Woody et al., 1983; Oltjen et al., 1971; Guenther et al., 1965). Buchanan-Smith et al. (1989) recommended a two phase feeding program in which roughages are used during the growing phase followed by grain diets during the finishing period as the most effective way of decreasing expensive grain or concentrate use in cattle. However, the effect of changing the level of concentrate (energy) at different stages of the growing period has not been adequately exploited for intact males.

The objective of this study was therefore to examine the effect of high or low concentrate, and the changing of diets during the postweaning growing period on carcass characteristics of young intact beef bulls.

B. MATERIALS AND METHODS

Experimental design

The breed groups used, design of the experiment, dietary treatments and the management of the animals were as described in chapter 2 (page 19). Following the 168 d performance-test, all the bulls were fed the high concentrate diet until they were slaughtered based on condition score (for Canada grade A1).

Slaughter and carcass evaluation

Thirty-three SY2 bulls were available for this study. Since condition score determined time of slaughter, sampling within the prefinishing (feedlot) diets was not random and therefore the effects of prefinishing diet and time of slaughter were confounded. Bulls were transported to the packing plant for slaughter in Edmonton, Alberta in three shipments (70, 75 and 103 days after the 168 d performance test, respectively).

Bulls were fasted for 24 hours, then trucked 150 km to a commercial packing plant in Edmonton, where they were weighed and slaughtered within a few hours of arrival. Slaughter weights ranged from 495 to 745 kg for these bulls. Carcasses were chilled overnight after which carcass measurements were collected by an Agriculture Canada grader. The appraisal form used was the standard ML 107 (blue tag) appraisal devised for record of performance testing, which consisted warm carcass weight, grade, meat colour, marbling score (range 1-10, higher numbers mean less visible marbling), area of longissimus muscle (ribeye area) at the 12/13 rib interface and fat cover at three positions over the longissimus muscle at the quartering (12-13th ribs). A 10-11-12th rib joint was removed from the right side of each carcass, trimmed according the method described by Hankins and Howe (1946), and separated into fat, muscle and bone. The weight of each component was recorded. Dressing percentage was calculated as (warm carcass weight/live weight) x 100.

Statistical analysis

A single factor (prefinishing diet) model was fitted to the data. The data were analyzed using the Statistical Analysis System (SAS, 1985) GLM procedure under model type III using a fixed model with diet as the main effect. An extension of Tukey's procedure (Steel and Torrie, 1980) was used for mean comparison whenever a significant ($P<0.05$) F test was found.

C. RESULTS AND DISCUSSION

Bulls were shipped to slaughter according to the schedule shown in Table 4.1.

There was a notable prefinishing diet-induced difference in days to A1 finish (Table 4.2). Bulls on **HH** and **LH** diets required the same number of days on a finishing diet to reach A1 finish and similarly bulls on **HL** and LL had comparable values. The difference in time to A1 finish between the two groups (HH,LH and HL,LL) was statistically significant ($P<0.05$) as expected. These observations showed that Bulls on HH and LH diets were 'ready' for slaughter two weeks earlier than those on either HL or LL diets as expected. However, the economic importance of this statistical difference was not evaluated in the present study.

Differences between prefinishing diets for live weight and warm carcass weight were significant ($P<0.05$; Table 4.2) although this effect was confounded with time (age) at slaughter. The prefinishing dietary treatment was not a significant ($P<0.05$) source of variation for dressing percentage. Similarly, cutability, grade fat, average fat and marbling score were not significantly ($P>0.05$) affected by the prefinishing dietary treatment (Table 4.2). It is probable, however, that the effects of the dietary treatments on the above mentioned traits had been partially removed since all the bulls were given a high concentrate diet until slaughtered. The possibility that the small sample size within each prefinishing dietary regimen might have contributed to the failure of detecting differences between the prefinishing dietary treatments could not be discounted. However, bulls on HH prefinishing diet were significantly ($P<0.05$) heavier than those on LL with no significant ($P>0.05$) difference when compared to bulls fed the other two diets (HL and LH, Table 4.2) . The same results were obtained for warm carcass weight.

This was partially due to the fact that some of the bulls on HH and LH were past A1 grade at the firs: slaughter date (37.5% and 27.3%, respectively), indicating failure accurately condition score for A1 carcass grade.

Bulls raised on HH prefinish g diet had significantly ($P<0.05$) lower muscle:fat ratio in the rib joint compared to those raised on HL diet. The result shows that bulls raised on high concentrate prefinishing diet had more fat and, therefore, less muscle in the rib joint than those on low concentrate. This effect may be overcome by a subsequent finishing period on a high concentrate diet. The result confirmed dietary level of concentrate manipulation effect on carcass characteristics in beef bulls. These results are generally in agreement with previous researches which have demonstrated that cattle fed on high concentrate diets usually have heavier carcasses because of increased fat deposition (Prior et al., 1977). The result is in agreement with the conclusions of Smith et al. (1977) who concluded that feeding regimens affected carcass composition in steers.

The distribution of carcass grades, revealed that all the bulls raised on the HL and LL diets graded A1 as expected (Table 4.3). This result agrees with that of Oltjen et al. (1971) for steers fed a low concentrate diet in both periods of the test among bulls. Among bulls on the HH diet 75%, 12.5%, and 12.5% graded **A1**, **A2** and **B1**, respectively.

Among bulls on LH 72.7 % graded A1 and the remaining bull carcasses graded either A2, B1 or B2 in equal proportions of 9.1% each. Generally, bulls on a low concentrate prefinishing diet finished at lighter weights than those on high concentrate.

Only one dark cutter (B2) was found and only in bulls from the LH diet. These results suggest that bulls can be successfully raised on low concentrate prefinishing diets followed by a period of feeding high concentrate finishing diet to achieve good carcass grades at lower carcass weights. It was possible to achieve optimum carcass fat levels (defined as Canada grade A1) on all four prefinishing diets when diet was elevated to a high concentrate finishing diet. It is concluded, therefore, that prefinishing diet could be manipulated to ensure optimum fat at optimum carcass weight as dictated by the market conditions.

Table 4.1. The number of bulls and days required for finishing following the test period within dietary regimens.

Day*	Dietary regimens			
	HH	HL	LH	LL
70 days	8	1	11	3
75 days	0	3	0	4
103 days	0	1	0	2
Total	8	5	11	9

*Days after the 168 day performance-test

Table 4.2. Least squares means and standard errors for carcass characteristics within dietary regimens.

Item	HH	HL	LH	LL
no. of bulls	8	5	11	9
Time to Al finish, d	240.0±2.8^{b}	255.6±3.6^{a}	240.0±2.4^{b}	254.0±2.6^{a}
Live wt., kg	629.6±18.2^{a}	581.5±23.8^{ab}	582.5±15.9^{ab}	547.3±18.1^{b}
Warm carcass wt., kg	380.2±10.9^{a}	336.6±14.2^{ab}	349.9±9.6^{ab}	317.5±10.8^{b}
Dressing percentage	60.1±0.6	58.5±0.7	59.7±0.5	58.5±0.5
Ribeye area, cm^{2}	16.1+0.6	16.7±0.9	14.5±0.5	14.5±0.7
Cutability, %	66.1±1.2	68.7±1.6	64.8±1.0	64.8±1.2
Grade fat, mm	4.1±0.6	4.0±0.8	4.5±0.5	5.6±0.6
Average fat, mm	5.4±0.6	4.0±0.9	5.4±0.5	6.3±0.7
Marbling score[2]	7.5±0.2	7.8±0.3	7.4±0.2	8.0±0.2
Muscle:fat	2.5±0.2^{b}	3.3±0.2^{a}	2.7±0.2^{ab}	2.8±0.2^{ab}
Muscle:bone	3.0±0.2	3.2±0.2	3.1±0.1	3.4±0.1

[2] 1, most marbled; 10, least marbled.

[a,b]Means in rows having the same letter do not differ significantly at $p<0.05$.

Table 4.3. Distribution of carcass grades within dietary regimens.

Carcass	Dietary Regimens							
	HH		HL		LH		LL	
grade	no.	%	no.	%	no.	%	no.	%
A1	6	75	5	100	8	72.7	9	100
A2	1	12.5	0	0	1	9.1	0	0
B1	1	12.5	0	0	1	9.1	0	0
B2	1	12.5	0	0	1	9.1	0	0

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CHAPTER 5. THE EFFECT OF POSTWEANING LEVEL OF CONCENTRATE ON THE HEALTH STATUS OF BULL CALVES IN THE FEEDLOT[6]

A. INTRODUCTION

A number of factors have been reported to affect the health status of feedlot bull calves. Age at weaning (Cole et al., 1979; Cole et al., 1982; Makarechian and Kubisch, 1988), management (Andrews, 1978) and unfamiliar rations (McKercher, 1978) are some of the factors that have been reported to affect both morbidity and mortality rates in feedlot calves. Harmful environmental factors (including feeding and management factors) generally predispose the animals and allow the micro organisms to express their full pathogenicity by decreasing the resistance of the animal to infection (Wiseman, 1978). Even though the plane of nutrition has been mentioned in the literature concerning its possible adverse effects on the health status of feedlot bulls (Perry, 1980) there is limited information on the subject as sick animals are generally removed from feedlot experiments and the duration of sickness and the rate of mortality are not usually reported.

It is important to identify as many managerial factors as possible that may affect the performance of feedlot calves so that optimization of these factors result in a more efficient beef production system. In this regard therefore, the main objective of this aspect of the feedlot study was to examine the effects of postweaning level of concentrate and change

[6]A version of this chapter has been submitted for publication. Mwansa, P. B., M. Makarechian and R. T. Berg. Canadian Veterinary Journal.

in the level of concentrate fed during the feedlot test on the health status of feedlot bull calves.

B. MATERIALS AND METHODS

The study was conducted during two consecutive years (1988 and 1989), using the experimental beef cattle herd maintained at the University of Alberta ranch at Kinsella, Alberta. The calves were born in April and May and were raised on pasture until weaning in early October without creep feeding. A total of 224 bull calves belonging to two multibred Beef Synthetic breed groups were used in the experiment.

After calving, the calves were given an injection of vitamin A,D and E supplements. The calves were vaccinated against clostridial diseases (Jasvax 8), infectious bovine rhinotracheitis (IBR) and parainfluenza 3 (PI3) at approximately two months of age (Bovishield/IBRPI3). They were given booster vaccinations in early October in both years.

The experimental design, breed groups and nutritional management were as described in Chapter 2, page 19.

During both the adjustment and feedlot periods, the incidence of sickness among bulls was recorded. Animals were closely monitored for signs of disease/stress such as; going off feed, isolation, nasal discharge, coughing and sneezing, unsteady gait, bloat, droopy ears and general ill health by the ranch staff. Temperature was taken and recorded for suspect animals. The occurrence of disease was considered as such if animals required treatment either by the ranch staff or by a veterinarian.

Final diagnosis of each case was made by a veterinarian. Animals were kept on treatment until clinical signs of the disease disappeared. As the experiment was only a part of a larger feedlot study, control of widespread respiratory infections was exercised. Therefore, the whole pen (7 animals/pen) was treated against the disease if more than 4 of the 7 animals in a pen showed clinical signs of disease. Within each year, data were analyzed separately since there was much disparity in the incidence of disease between the two years.

Fisher's Exact Method as described by Bradley (1968) was applied in order to test the significance of the effect of level of concentrate in feedlot diet and change in the same on health status of feedlot bull calves. In comparing the average number of days during which animals required treatment, the t-test for independent samples and unequal variances was employed, as described by Steel and Torrie (1980).

C. RESULTS AND DISCUSSION

The incidence of disease and average period of treatment in each period are depicted in table 5.1. In the first period of the 1987/88 feedlot test (first year), one calf from each of the treatment groups was treated for infected injection site and another from the low concentrate group was treated for a bruised shoulder. One case of bloat was observed in the low concentrate group. In total, 5.36% of calves in the L group required treatment compared to 1.79% in the H group. However, the difference was not statistically significant (P>0.05). In the second period, a higher incidence of bloat was observed in bull calves that were switched from L to H (3 calves) compared to 1 in calves that were maintained on H during both periods of the test and 0 in either those on L during both periods of the test or those switched from H to L. These differences were, however, not significant ($P>0.05$) .

In the first period of the 1988/89 feedlot test (second year), all (100%) the calves in the H group required treatment compared to only 4 (7.14%) in the L group (Table 5.1); and this difference was highly significant ($p<0.0001$). The main cause of sickness was inflammation of the respiratory tract, particularly pneumonia. The maximum possible morbidity rate (100%) in the H group was somewhat exaggerated by the fact that all the animals in a pen in which at least 5 of the animals showed symptoms of respiratory tract infection were treated and therefore considered sick. The high incidence of respiratory tract infections was not unexpected, as Church and Radostits (1981) in an Alberta-wide survey of feedlots reported that respiratory diseases accounted for 59% of total morbidity in feedlot cattle.

Although the chance of exposure to the pathogenic organisms was practically the same for all the bulls as the dietary treatment was assigned randomly to the pens and the pens were adjacent to each other with no barrier to prevent the direct contact between animals in adjacent pens and flow of air and droplets from one pen to another, nevertheless, the respiratory infections appeared mainly in bull calves which were on the high concentrate diet. The results suggested that, bulls receiving high concentrate diet had a much greater susceptibility to respiratory infections compared to those on low concentrate.

Generally, a low incidence of disease was observed in the second period of the 1988/89 feedlot period and again 1 case of bloat was observed in the group that was switched from L to H. Year was a significant factor in causing illness as 61 animals required treatment for respiratory infections in the 1988/89 feedlot period compared to none in the previous year. The reason for the high incidence of respiratory infections in the second year of feedlot study compared to the first was not clear as analysis of the weather records (Temperature, both absolute and daily changes; Humidity, both absolute and daily changes alone or a combination of both) of the two years could not explain these results. Based on the health records for the past three decades, respiratory infections of calves on an epidemical scale are not observed regularly every year at the University ranch. In both years, the average length of treatment required for calves on low and high concentrate diet were comparable.

Breed group effect was not significant (P>0.05) as both breed groups exhibited fairly similar morbidity rates. Apparently, calves on high concentrate diet had been affected by some stressors which had weakened their body defence mechanism and consequently had become more susceptible to respiratory tract infections compared to those on low concentrate-high roughage diet. McKercher (1978) considered unfamiliar feedlot rations as stressful to young bull calves. Since stressful conditions weaken the immune system of the animal (Wiseman, 1978), the high concentrate diet may be more stressful compared to the low concentrate-high roughage diet for calves coming from a cow/calf operation. Considering the 1988/89 results, the incidence of pneumonia was higher during the month of December, but again no plausible reason could be found for this.

Further research on this subject involving higher numbers of experimental animals and including microbiological and serological studies to identify the specific pathogens and the antibody titres would be necessary to identify the main factors. However, the results of this study suggest that bull calves raised on a high concentrate diet have a higher susceptibility to respiratory infections compared to those receiving low concentrate diet, and that bull calves raised on a low concentrate diet and switched to a high concentrate diet are more likely to experience digestive disturbances (bloat). This is likely to result in greater losses and higher costs to the producers which would have to be taken into account when considering feedlot diets.

Table 5.1. Disease incidence in the feedlot for bulls fed a high or low energy diet during two years of feedlot study.

Item	Year 1		Year 2	
	High concentrate	Low concentrate	High concentrate	Low concentrate
no. of bull calves	56	56	56	56
Period I[b] (Nov 10-Jan 26):				
Number of bulls requiring treatment for:				
Respiratory infection	0	0	56	4
Bloat	0	1	0	0
Other reasons	1	2	0	0
Total	1 (1.79)[a]	3 (5.36)	56 (100)	4 (7.14)
Period II[c] (Feb 5-April 22):				
treatment for:				
Respiratory infection	0	0	0	1
Bloat	4	0	1	0
Other reasons	0	0	1	0
Total	4 (7.14)	0 (0)	2(3.57)	1(1.79)
Average length of treatment required (days)	1.0±0	1.0±0	2.13±1.32	1.40±0.89

[a]Figures in parenthesis are percentages.
[b]Period 1 (Oct 25-Jan 12) in year 2.
[c]Period II (Jan 26-April 12) in year 2.

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CHAPTER 6. GENERAL DISCUSSION AND CONCLUSIONS

In designing performance test programs a controversial question among geneticists and animal breeders revolves around the choice of the nutritional environment under which to practice selection. The main hypothesis has been that performance in a favourable environment is dependent upon a different genetic basis from performance in a less favourable environment (Fowler and Ensminger, 1960). In other words, the phenomenon of genotype x environmental interaction, if it existed, would give different interpretations to the results of a performance test.

The results of this study showed that, generally the relative rates of growth of bulls were different in different nutritional environments. Bulls maintained their ranking for growth rate fairly well in the two periods (77 days each) of the performance test when they were fed similar diets in the two periods. The rank correlation coefficient was low and nonsignificant when they were fed different diets in the two per (Chapter 2, page 29). This might suggest that different gene array prominent during the two periods when different diets were fed (H 1987). It is probable that, for bulls on the high concentrate diet, that condition high appetite were prominent and for bulls on the lo concentrate diet, genes that condition efficiency of feed utilization were brought into prominence (Falconer and Latyszewski, 1952). The significance of these results would be that, when defining a superior animal for growth potential due regard must be given to the environment wherein the animal was evaluated (Dempfle and Grundl, 1988).

Based on these results alone, it was not attempted to offer a recommendation regarding which of the two diets (feeding high or low concentrate diet throughout the test period) would be a preferred choice. It might be recommended, however, that prospective herd sires should be evaluated in a nutritional environment wherein their progeny are expected to perform.

In search of more information to broaden the scope of these results another study was undertaken with the knowledge that a bull should not only possess superior genetic potential for fast gains but must also be able to bring about timely conception in cows. The ability of a bull to do this depends upon three primary factors which are often affected by growth and management (Walker, 1967). These are: the ability to breed, the desire to breed and the formation and ejaculation of semen of satisfactory quality. In this regard therefore, bulls were evaluated for scrotal circumference, sex drive and semen quality on the four dietary regimens in order to assess the effect of level of concentrate and the change in level of concentrate during the performance test on the reproductive potential of young bulls.

Results of this study suggested significant differences in sex drive due to year effect. Semen characteristics were also observed to vary with age. The older bulls had generally larger scrotal circumference, higher proportions of sperm exhibiting progressive motility, and lower proportions of abnormal sperms (Chapter 3, pages 45, 51). Bulls on high concentrate diet had the largest scrotal circumference but the poorest semen characteristics. Bulls whose diets were switched and those which were maintained on the low concentrate diet had better semen characteristics (lower proportion of abnormal sperms) compared to bulls which were fed a high concentrate diet throughout the performance test period.

It is well established that for normal sperm cell development, it is necessary that the testicles be maintained at a temperature below normal body temperature. To accomplish this, nature has developed an elaborate radiator system with a built-in thermostat to control it. There have been suggestions that fatter bulls have larger scrotal circumference due to heavy deposition of scrotal fat (Sorensen, 1979). Heavy deposition of fat in the scrotum has been reported to interfere with the thermo-regulatory function of the scrotum which might consequently bring about degeneration of the sperm-producing seminiferous tubules (Walker, 1967). The excessive or prolonged feeding of high concentrate diet may affect the output of Interstitial Cell Stimulating Hormone and Testosterone (Walker, 1967). It might be possible that this observed dietary effect on semen quality was due to both physical (deposition of scrotal fat) and physiological (affecting hormone output) effects. In this study the patterns of backfat accumulation approximated that of scrotal growth within dietary regimens (Chapter 2, page 55).

The whole aim of evaluating bulls for growth and reproductive potential in performance testing is to maximize the efficiency of meat production for our ever increasing world population. In this regard therefore, bulls were evaluated for carcass characteristics following a period on a high concentrate finishing diet after the four prefinishing dietary treatments.

Since the samples evaluated at this point were not randomly chosen from the four treatment groups at all the slaughter times (bulls were taken out for slaughter only when they were condition scored to grade Canada A1) the effect of prefinishing nutrition and age of bull on carcass characteristics were confounded. However, the results suggested that bulls raised on different prefinishing feedlot diets could be finished on a high concentrate diet and still obtain acceptable carcass grades (Chapter 4, page 66) at different weights. Generally, bulls raised on a low concentrate diet either throughout the entire test period or in either half of the test had more muscle in the rib joint compared to those raised on a high concentrate diet throughout the performance test period. It is therefore, suggested that prefinishing feedlot diets could be used to manipulate production to ensure optimum fat at optimum carcass weight as dictated by the market conditions.

In the final study of this feedlot experiment, it was noted that bulls raised on a high concentrate diet were more susceptible to respiratory infections during the first period of the test compared to those on low concentrate (Chapter 5, page 76). In the second year of this experiment, all the bulls on high concentrate were treated for pneumonia compared to four in the low concentrate group. The economic implication of these results is obvious. For this part of the study, it is concluded that bulls raised on high concentrate diet in performance testing programs would be more susceptible to respiratory infections.

On the whole, the results of this experiment would lead to the recommendation that it would be advisable not to test bulls under a high concentrate diet because of the negative effects of high concentrate diets on the reproductive and health status of young bulls. All the four feedlot diets had comparable values for feed efficiency at the end of the 168 d study. The economic viability of a low concentrate-high roughage diet may differ in different regions, and should be examined for each particular region.

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Appendix 1. Feed Evaluation.

Samples of hay and concentrate diet were collected and analyzed by the Alberta Agriculture soil and nutrition laboratory.

Dry Matter (DM). Small (10g) samples were prepared and there weights (W1) taken. They were then heated at 100°C for 24 hours to a constant weight (W2). DM% was then calculated as (W2/W1) x 100.

Crude Protein (CP). Small (5g) dried samples were digested (Kjeldahl process) in concentrated sulphuric acid in the presence of potassium sulphate until all organic matter was destroyed. The digest was neutralized with sodium hydroxide, distilled into a known quantity of a standard acid solution and titrated with standard alkali to determine the amount of nitrogen (X) in the sample. Since protein contains about 16% nitrogen, total nitrogen (6.25X) equals Crude Protein in the sample.

Acid Detergent Fibre (ADF). To fractionate feed into relatively digestible and indigestible portions, Van Soest (1967) method was used. Ground feed samples (1g) were digested with an acid detergent solution (49.04g sulphuric acid and 20g acetyl trimethyl ammonium bromide per litre for an hour and then filtered). The insoluble or residues make up the acid detergent fibre and consists mainly of cellulose, lignin, and variable amounts of silica.

Digestible Energy (DE). In hay samples, digestible energy was estimated by fitting the proportion of ADF into the following equation (Mathison et al., 1982):

Mcal of DE/kg of DM = 3.40-0.02(%ADF) where as that for concentrate was estimated from average DE values of the composite grains reported by NAS (1976).

APPENDIX 2. Composition of hay and concentrate diets.

Composition of Hay

Chemical composition	-Per kg of DM
DM, %	90.00
Digestible Energy, MJ	9.79
Crude Protein, g	75.60
Acid Detergent Fibre, g	361.80

Composition of the concentrate diet (H)

Ingredients	Air-dry Composition
Barley, %	63.00
Oats, %	22.00
Alfalfa Pellets, %	10.00
Bull Premix*, %	5.00
Total	100.00

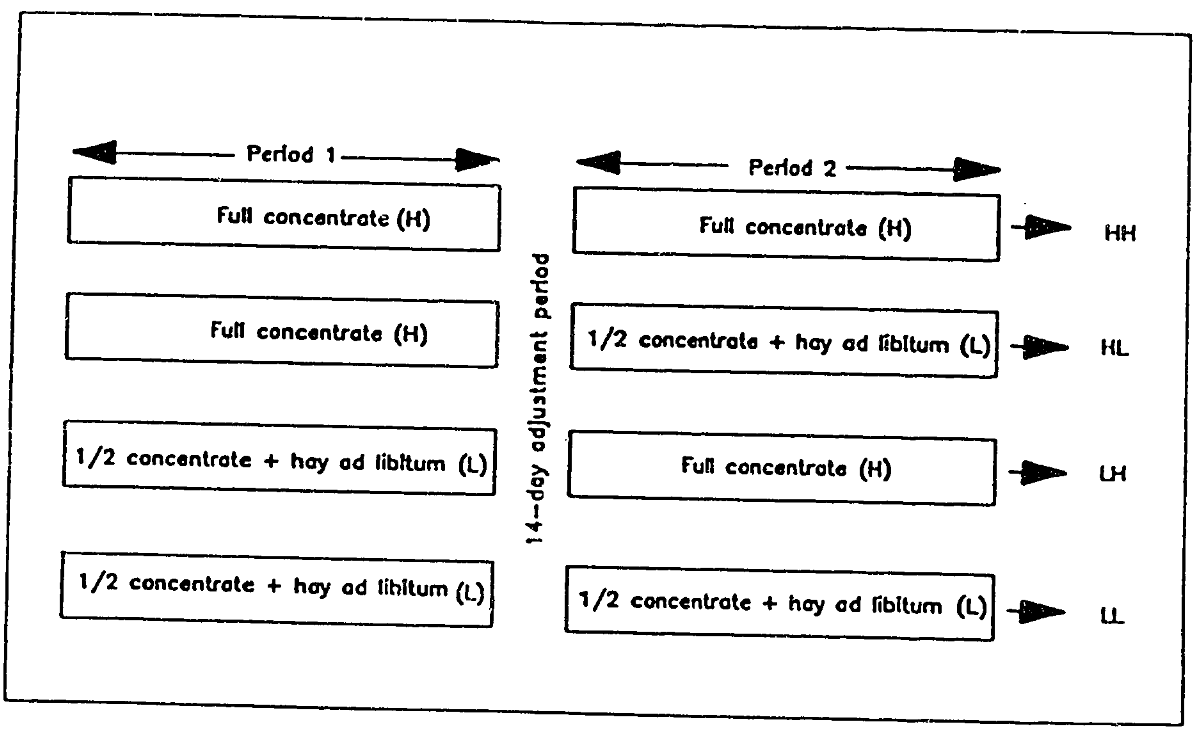
Chemical Composition	-Per kg of DM-
DM, %	90.00
Digestible Energy, MJ	14.24
Crude Protein, g	133.90
Acid Detergent Fibre, g	122.00

Composition of Bull Premix*

Ingredients	Percent
Canola meal	62.40
Molasses, beet	2.20
Salt	6.00
Urea	6.00
Calcium Carbonate (Limestone)	22.00
Vitamin A,D (10,000,000) I.U A/kg	1.00
Rumensin (132.2g/kg)	0.40
Total	100.00

*This premix constituted 5% of the total concentrate (H) diet.

Appendix 3. Schematic design of the experiment for each year and breed group.



APPENDIX 4. Average Breed Percentages in Calves Born at Kinsella[7] from 1962-1988.

Breed	1962	1970	1974	1978	1982	1984	1986	1988
Beef synthetics #1:								
Angus	41.4	37.6	36.0	35.7	36.8	36.9	36.2	35.6
Brown Swiss	-	4.7	4.5	4.5	5.2	5.0	5.3	5.7
Charolais	16.8	35.1	34.4	34.7	34.1	33.0	32.3	31.4
Galloway	40.3	20.3	21.4	21.7	20.6	20.7	21.0	20.9
Others	1.5	2.3	4.0	3.4	3.3	3.7	6.1	6.4
Beef synthetics #2:								
Angus	-	-	-	-	11.1	10.0	15.3	12.1
Charolais	-	-	-	-	9.4	7.8	8.8	8.0
Galloway	-	-	-	-	7.4	4.4	6.7	5.1
Hereford	-	-	-	-	65.0	69.0	59.8	60.1
Others	-	-	-	-	7.1	8.3	9.4	14.7

[7]Adapted from Berg et al., (1990).

APPENDIX 5. The Spearman's Correlation Coefficient.[8]

The Spearman's correlation coefficient (Spearman, 1904) is one of the commonly used nonparametric methods of detecting associations between two variables. Its use is usually restricted to a single block. However, there are circumstances where the joint distribution of the two variables of interest (X and Y) is affected by the value of a third variable, called a blocking factor. The Spearman's correlation coefficient can then be estimated as follows: The data are first ranked. The Spearman correlation is then computed using the following formula.

$$r_k = \frac{\Sigma(\mu i - \mu)(v_i - v)}{[\Sigma(\mu i - \mu)^2 \quad \Sigma(v_i - v)^2]^{½}} ,$$

where,

μ_i is the rank of X_i, v_i is the rank of Y_i and the average ranks are used if there are ties. r_k is the Spearman's rho in block *k*, the rank analogue of the product moment correlation coefficient. The probability values for the correlation are obtained by treating $(n-2)^{½}p/(1-p^2)^{½}$ as coming from a *t* distribution with n-2 degrees of freedom, where *p* is the appropriate correlation.

[8]Adapted from SAS User's Guide (1985)