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To the Graduate Council:

I am submitting a thesis written by Joseph John Knapka entitled "The Effect of Varying Levels of Nutrition on Growth, Development, and Fertility of Beef Bulls." I recommend that it be accepted for nine quarter hours credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

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THE EFFECT OF VARYING LEVELS OF NUTRITION ON GROWTH,
DEVELOPMENT, AND FERTILITY OF BEEF BULLS

A Thesis
Presented to
the Graduate Council of
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In Partial Fulfillment
of the Requirements for the Degree
Master of Science

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CHAPTER I

INTRODUCTION

The statement, "a bull is half the herd," has been made by many people associated with the beef cattle industry; yet, there is an absence of scientific papers appearing in the literature concerning the development of herd sires. The majority of performance testing programs reported for beef bulls have been progeny tests. Progeny tests are useful in predicting a bull's prepotency, but are time consuming and expensive. Not only does the bull have to reach sexual maturity, he must then sire adequate numbers of progeny for purposes of evaluation. A program is needed which will test a bull's performance under various conditions during his developmental period in order to provide an early indication of his productive potential.

A large majority of post-weaning performance tests which have been designed for beef cattle have emphasized that the best way to evaluate the gaining and feed utilization ability of an animal is to feed a maximum amount of grain for a period of approximately 140 days. It has generally been accepted that the performance of beef cattle during this 140-day period of consuming large quantities of high-energy feeds is indicative of future productive ability; these data have been extensively used as criteria for the selection of breeding stock.

Beef cattle have the unique ability, with the assistance of rumen microorganisms, to convert low-cost roughages into a popular

high-priced commodity. Since there is an abundance of nutritious, low-cost feeds available in the Southeastern portion of the United States, it is economically sound to incorporate large quantities of roughages into beef cattle rations.

Since it has been established that high-roughage rations are economical for beef cattle, it seemed appropriate that a program be considered which utilizes an optimum amount of roughage during the developmental period of beef bulls. In order to acquire the amount of finish desired by the consumer, a steer must possess the ability to gain in the feed lot as well as on high-roughage rations. Likewise, a prospective herd sire should not only have the ability to gain on a high-roughage ration, but he should also demonstrate a high productive potential in the feed lot.

Since the level of feeding during the growing period may have an effect on future reproductive performance, a program for the development of bulls must consider first the effects on the future fertility of the bull.

In order to obtain more data on methods of developing bulls, a Record of Performance Test was initiated by the Animal Husbandry-Veterinary Science Department at the University of Tennessee. In the initial report Anderson (1962) concluded that the most desirable program of those tested for developing bulls consisted of three periods:

1. A 140-day wintering period in which the basic ration consisted of a full-feed of corn silage, 2 lb. of alfalfa hay, and 5.5 lb. of concentrates.

2. A pasture period of approximately 90 days in which the bulls were allowed to consume daily an average of approximately 1 lb. of grain per 100 lb. of body weight.

3. A 98-day full-feed period.

Since bulls wintered on 5.5 lb. of concentrates were in a highly satisfactory condition at the conclusion of the test, the question of whether lower amounts of concentrates could be fed during the wintering period naturally arose.. Therefore, the present work was designed to determine the effects on growth rate, productive performance, and fertility of reducing the amounts of concentrates from 5.5 lb. to 2.5 lb. during the winter period and feeding silage and hay as in previous tests.

CHAPTER II

REVIEW OF LITERATURE

Methods of Evaluating Bulls

Throughout the years various methods have been introduced for performance testing beef cattle. The fact that few of these programs have dealt directly with the development of bulls is due, at least in part, to the custom of selecting herd sires on show ring performance. Even though many highly successful beef cattle breeders have exclusively selected sires on such a criterion, this method of selection has little scientific basis as described by Clark et al. (1943).

Actually the show ring came into being as a side light of performance testing of beef cattle. Early breeders frequently argued as to which had produced the fattest cattle, and a disinterested third party was generally chosen to settle the dispute. Realizing the advertising value of such a contest, fat cattle shows became part of the tournaments in each locality. From this beginning our present-day highly specialized county, state and national shows have arisen. The testing of beef cattle for efficiency of production has been lost by the wayside and it has been replaced by unfounded beliefs in the ability of men to see (in) an animal the efficient producer without testing for this characteristic.

After surveying all major national shows for 12 years, Holbert (1932) proposed a system of evaluating sires on the basis of show ring winnings of their offspring. He suggested that the top ranking sires be more widely publicized rather than the premium winners themselves, since a high percentage of the winners were sired by relatively few bulls.

Since Sheets (1932) deplored the idea of selecting breeding cattle on unscientific show ring performance, he formulated a record of performance system based on the amount of meat produced per 100 lb. of total digestible nutrients eaten from birth, carcass grade, and tenderness of the cooked meat.

Following a critical review of the methods of measuring performance of beef cattle suggested by Holbert (1932) and Sheets (1932), Winters and McMahan (1933) advocated that average daily gain from birth to one year of age and a quality score based upon a slaughter grade as determined by a committee would be the most advantageous criteria on which to base a performance testing program.

From data that were accumulated from calves that were weaned at a constant age (252 days) and slaughtered at a constant weight (900 lb.), Black and Knapp (1936) calculated various correlation coefficients. Using these data as a basis, the authors ascertained that a performance testing program based on efficiency of gain and a quality score on carcass grade was most indicative of the sire's production potential.

In a later paper Black and Knapp (1938) compared the performance testing programs proposed by Sheets (1932), Winters and McMahan (1933), and Black and Knapp (1936) on 147 steers located at three different stations. They concluded that the program advocated by Black and Knapp (1936) based on efficiency of gain from 500 to 900 lb. and a quality score on carcass grade offered a more accurate means of selection between sires on progeny performance test mainly because results obtained were influenced less by the dam's milk production.

Clark et al. (1943) collected data on weaning weight, feed lot gain, market weight, percentage of bloat, carcass grade, sale price, and gross return on eight randomly selected steers by each of eleven Hereford bulls. A tabulation of these data provided a ranking of each sire and a judgment was made as to the performance merit of each sire on the basis of the factors tested.

Patterson et al. (1949) reported results of a 7-year study that was to determine the value of using sire and progeny testing as an aid to effective selection. During this period production data were collected on 814 young bulls and 104 heifers; and, after statistical analyses, these trends were reported:

1. The ability of rapid gain is highly heritable.
2. Selection based upon performance of the individual would prove the most effective in improving rate of gain in beef cattle.
3. Progress toward high production performance would be expected from mating superior performing animals irrespective of any predetermined breeding lines.
4. Practically no relationship exists between type score and gain ($r = -.041$).
5. Initial grade and final grade are fairly highly correlated ($r = +.724$).

Results of a 9-year classification system study reported by Ray and Gifford (1949) ascertained that (1) most animals remained in or near the same classification during their lifetime, and (2) seasonal differences in condition of finish had little influence on classification ratings.

During the past few years a considerable volume of data has been accumulated to indicate the heritability values for important characteristics in beef cattle. In his review article Warwick (1958) summarized all studies known to be reported and he presented average heritability percentage estimates as follows: birth weight, 41; weaning weight, 30; post-weaning feed lot gain, 45; efficiency of feed lot gain, 39; and weaning grades, 16. In the past five years comparable values have been reported by Lasley and Day (1960) and United States Department of Agriculture (1960).

Swiger et al. (1961) published data that indicated heritability estimates are influenced by different weaning dates, climatic conditions, and management practices. They found that a 168-day feeding period is necessary in order to obtain reliable heritability estimates for various traits during the post-weaning period of beef cattle.

A study to determine the number of progeny and the length of feeding period required to test beef bulls was conducted by Knapp et al. (1942). A minimum of eight weanling calves by a given sire fed for a minimum of 168 days was found to be a satisfactory progeny test.

Gregory et al. (1961) proposed a production testing program for beef bulls which would give final weights and grades at about the normal market age for a high percentage of slaughter cattle. This program consisted of feeding weanling bull calves during their first winter on a relatively low level of concentrate (4-5 lb. per head per day) and a full-feed of roughage. The following summer the bulls were provided with a higher level of concentrates either on grass or in dry lots.

The reasoning behind this program was that bulls were developed at a high enough level of feeding over a long enough period of time for genetic differences in growth rate to be expressed. Because of compensatory gains, the authors believed there was a possibility of selecting calves whose dams were poor milk producers if post-weaning gains were used as the primary criteria of productive performance. To overcome this situation they recommended that the pre-weaning and post-weaning gains should be combined and adjusted to a 550-day weight which could be used to measure growth rate of the bull. As an alternative method, these authors proposed that gains made during a short period of time (140-164 days) immediately after weaning be adjusted to 365 days before being used for measuring growth rate. At the conclusion of this paper, the following principal features of a good record of performance program were given:

1. All animals given equal opportunity.
2. Systematic, written records kept on all animals in a herd.
3. Records adjusted for all known sources of variation such as age of dam, age of calf, and sex.
4. Records used in selecting replacement stock and in culling poor producers.
5. Nutritional programs and management practices be practical and compatible with those where progeny of herd are expected to perform.

Anderson (1962) and Hobbs and Anderson (1962) reported results of the first extensive study of various methods for the development of beef bulls. The four different systems of development prior to the full-feeding period were as follows:

AA - Full-feed of grain and limited quantities of silage and alfalfa hay during the winter, limited amounts of grain on pasture.

BA - Full-feed of silage and limited amounts of grain and alfalfa hay during the winter, limited amounts of grain on pasture.

AB - Full-feed of grain and limited quantities of silage and alfalfa hay during the winter, no grain on pasture.

BB - Full-feed of silage and limited amounts of grain and alfalfa hay during the winter, no grain on pasture.

The third phase of each system was a 98-day feed lot period during which time all the bulls were fed a full-feed grain and limited quantities of roughage. During the three years prior to the fall of 1961, three replications of treatments AB and BB and two replications of treatments AA and BA were completed.

During the winter period the bulls on the A treatment had an average daily gain of 2.29 lb. compared with 1.97 lb. for bulls on the B treatment. This difference was highly significant ($P < .01$). The average daily gain during the pasture period was 1.10 lb., 0.48 lb., 1.62 lb., and 0.82 lb. for bulls on treatments AA, AB, BA, and BB, respectively. These treatment differences were found to be highly significant ($P < .01$), and a significant ($P < .05$) year x treatment interaction was reported. The average daily feed lot gains made by bulls on treatments AA, AB, BA, and BB for two years combined were 2.33 lb., 2.56 lb., 2.72 lb., and 2.56 lb., respectively. The only significant difference was between the means of treatments AA and BA ($P < .01$). The average daily gains for the three periods combined for bulls on treatments

AA, AB, BA, and BB were 1.94 lb., 1.85 lb., 2.09 lb., and 1.82 lb., respectively. Bulls on treatment BA outgained bulls on treatments AB and BB ($P < .01$) and treatment AA ($P < .05$). The authors stated, "The extra grain fed to bulls on AA and AB treatments during the winter did not increase the overall test gain for these treatments when compared to treatments BA and BB, respectively."

The total feed costs per head for the three periods combined were \$142.51, \$131.11, \$135.90, and \$115.24 for treatments AA, AB, BA, and BB, respectively. *omit* Treatments had no marked effect on type grade; however, condition grades were considerably higher at the end of the test for bulls on treatments AA and BA.

The authors concluded, "A system similar to that designated as BB was the most economical and that this treatment made the greatest use of roughages; however, it also produced the lowest gains of all methods tested." They further ascertained, "Although the cost per head for treatment BA was about the same as the cost for treatments AA and AB, the use of treatment BA resulted in significantly greater gains than either treatment AA or treatment AB."

Production Programs for Slaughter Cattle

In an early three-phase program for the development of steers, McCampbell et al. (1929a) reported an experiment in which 20 weanling steer calves were fed for 325 days. During the 135-day winter phase the basic ration was 1 lb. cottonseed meal and 2 lb. alfalfa hay per head per day plus corn silage according to appetite. In addition, one-half of the steers (Lot I) received 4.66 lb. of corn per head per day,

while the other half (Lot II) received no additional concentrate. The average daily gains for steers in Lot I and Lot II were 2.09 and 1.55 lb., respectively. During the 90-day grazing phase, when all steers were treated identically, the daily gain was 0.85 lb. for Lot I and 1.26 lb. for Lot II. While on the 100-day feed lot phase, in which all steers were fed similarly, Lot II outgained Lot I 2.82 to 2.53 lb. per day. Actually the total gain over the entire 325 days was only 7 lb. greater for those steers receiving corn during the winter as opposed to those receiving on corn during that particular phase. The authors pointed out that, with the exception of the feed lot phase, the gain by the steers in Lot II was made primarily from low-cost roughages.

A replication of the preceding experiment was reported by McCampbell et al. (1929b). The only alteration was the increasing of the daily ration of corn for the Lot I steers during the winter from 4.66 to 5.00 lb.; however, the average daily gains during the winter and grazing phases were slightly higher for both lots in this second trial. In the feed lot the daily gain was 2.86 and 2.76 lb. for Lots I and II, respectively. The average daily gain for all three phases combined was 1.99 lb. for Lot I and 1.80 lb. for Lot II. It was pointed out that the steers in Lot II made greater use of inexpensive roughages than the steers in Lot I.

A three-phase program for finishing yearling steers that did not make use of any concentrates until the final phase was advocated by Dyer (1952). During the 135-day winter phase of this experiment, one group of steers (Lot I) was provided with a ration that consisted of

corn silage and red clover hay, while a similar group (Lot II) was maintained on bluegrass pasture. The steers in Lot I gained 1.5 lb. daily as opposed to 0.1 lb. for those in Lot II. Even though the steers in Lot II outgained the steers in Lot I during the 170-day grazing period, the steers in Lot I gained 80 lb. more during the two periods combined than those in Lot II. During the feed lot phase, the steers that had been wintered on corn silage and red clover reached the choice grade sooner than those that had been wintered on bluegrass pasture. These authors recommended that a management system which allows yearling steers as calves to gain 1.25 to 1.50 lb. daily during the winter is most conducive for rapid feed lot gains in Missouri.

[In an early experiment, Good (1926) wintered one group of yearling steers on corn silage according to appetite, while a similar group was fed 5-6 lb. of corn per head per day with no silage. Both groups were provided with the same amount of cottonseed meal and hay. After a grazing period in which both groups were treated alike, it was reported that the steers wintered on grain had an advantage of 0.06 lb. gain per head per day, yet the cost per hundredweight of gain was \$1.12 less per steer for the steers wintered on corn silage.

Miller and Morrison (1953a) reported three year's results of wintering calves with 2 lb. of corn (Lot III) versus wintering with no corn (Lot IV). Both lots received 1 lb. of mixed protein supplement, 4 lb. of mixed hay, and a full-feed of corn silage. The steers in Lot III gained 1.47 lb. per day as opposed to 1.15 lb. for steers in Lot IV. During a 100-day pasture period, in which neither of the lots

received any grain, the average daily gain was 0.77 and 1.04 lb. per day, respectively. Although the feed lot phase varied from 70-90 days, the steers that had been wintered on the highest energy ration outgained the others 2.24 to 2.17 lb. per head daily. For the entire 334 days, steers in Lot III gained 1.41 lb. per day and those in Lot IV gained 1.33 lb. per day. There was no appreciable difference in cost per head based on the feed prices used.

After studying modifications of the program outlined in the preceding paragraph for three years, Miller and Morrison (1953b) stated that there is no one plan for fattening steers, but that a feeding program based on pasture should include as many of the following conditions as possible:

1. Purchase feeders in the fall.
2. Winter entirely or largely on good roughages.
3. Graze 100 days or more on a good pasture.
4. Market from late September through December.

In a summary that included 13 experiments involving over 300 head of yearling steers, Duncan (1958) found that significantly greater gains were made by cattle on grass and grain than by cattle on grass alone. Returns per head over feed costs were greater on the average from steers receiving pasture only. A suggested method for producing slaughter beef was that of wintering heavy weanling calves on low-cost, high-roughage rations, pasturing them during the summer without grain, and finishing them in the dry lot for 56 days.

Castle et al. (1961) stated, "Rate of winter gain together with number of days on winter feed had a significant negative effect on subsequent summer gain." Similar data have been presented by Kincaid et al. (1945), Mott and Miles (1946), Marion et al. (1956), and Heineman and Keuren (1956). The above authors drew their conclusions from similar experiments in which cattle were wintered on various high-roughage rations then pastured for at least 100 days. Weber et al. (1947) and Lohrding et al. (1959) found that poor winter gains were compensated by faster pasture gains, and as a consequence, total gain was essentially the same regardless of high or low winter gains.

Knapp and Baker (1943) gave results obtained in two different years from limited and unlimited feeding of steers for the purpose of testing performance. Analysis of variance showed that on limited grain feeding the sire groups were significantly more alike than would be expected by chance; whereas, on unlimited grain feeding the sire groups were significantly different from each other. They concluded that ad libitum or full-feeding was the best method by which differences in ability to grow may be determined.

Practically every state sponsors a pre-weaning or post-weaning performance testing program for beef cattle. Most of the post-weaning record of performance tests that have been conducted use a standard period of full or ad libitum feeding as suggested by Knapp and Baker (1943) to measure the productive performance of beef cattle.

Nutritional Effects on Fertility of Bulls

Effects of varying levels of energy. The effects of lowered total digestible nutrients (TDN) intake on the spermatogenic capacity of growing bulls has been studied by Van Demark and Manger (1952) who employed the use of the partial-exhaustion technique. Partial exhaustions were repeated at 1, 4, 7, and 13 day intervals on bulls that were fed 60 per cent and 100 per cent of Morrison's TDN allowances.. These trials were conducted when the bulls were 384, 492, and 614 days of age. The intervals necessary to replenish the total number of sperm equal to that ejaculated at the initial partial exhaustion in the group of 100 per cent intake bulls were 12, 10, and 7 days at the respective ages. The rate of replenishment of the total number of sperm ejaculated by the 60 per cent intake bulls equal to those at the initial partial exhaustion of the first two ages was highly variable; however, replenishment was completed by 12 days at the third age. The authors concluded that the rate of replenishment increased as body weight and age increased.

Mann and Walton (1953) observed no decrease in the volume or density of the semen or the motility and morphology of the spermatozoa produced by a 5-year-old Dexter bull that was maintained for 23 weeks on a ration that caused him to lose 14 lb. per week. However, the secretory function of the male accessory glands was markedly affected by under feeding. The concentration of fructose and citric acid in the semen decreased to about 30 and 60 per cent, respectively, of the original pre-test levels; however, during the post-test recovery period of 25 weeks, the values for these compounds gradually returned to normal. As a result

of this study, these authors concluded that the male reproductive organs exert no large demands upon the general nutrient supplies of the body and there is no reason to suppose that these organs are more sensitive to nutritional factors than is the rest of the body.

Flipse et al. (1953) observed that sexual maturity was delayed 12 to 14 weeks in Holstein bulls ingesting 70 per cent of the recommended TDN allowances of Morrison as compared to bulls receiving 100, 115, and 130 per cent of these allowances. Tests of semen quality between 72 and 96 weeks of age indicated that the 70 per cent intake bulls were significantly lower than the other groups in concentration of spermatozoa, per cent initial motile sperm, rate of motility, and livability after 5 to 10 days of storage. Other semen characteristics not materially affected by treatment included volume, per cent live (unstained) spermatozoa, fructose content, and pH.

Bane (1954) observed a higher incidence of abnormal spermatozoa heads in the semen of bulls on a high plane of nutrition than those on a low plane.

Bratton et al. (1959) used slaughter experiments to determine the effect of various levels of energy intake on the gonads of the bull. Seventy-two young Holstein bulls were equally assigned to rations that provided 140 (high), 100 (control), and 75 per cent (low) of Morrison's recommended TDN allowances. Four bulls on each of the feeding levels were slaughtered at ages of 1, 16, 32, 48, 64, and 80 weeks. Detailed microscopic examinations of the seminiferous tubules revealed that two of the bulls on the high feeding level showed active spermatogenesis at

32 weeks of age. All bulls on each feeding level slaughtered at 48, 64, and 80 weeks of age showed very active spermatogenic tissue. However, on the low level of feeding, two of the bulls in the 48-week, two in the 64-week, and one in the 80-week group had not produced an ejaculate of semen when slaughtered.

Calculations were made which showed that the costs of the feed required to raise Holstein bulls to semen-producing age were \$164, \$84, and \$60 for the high, medium, and low levels, respectively.

Conclusions reached from these studies were: (1) body development and the onset of semen production in young bulls may be accelerated by a high level of feeding and retarded by a low level of feeding during early calfhood, and (2) a planned TDN intake as low as 60 per cent of Morrison's upper range of recommended allowances does not result in any permanent damage to the sperm-producing tissue; however, such levels of TDN do delay the onset of semen production.

Data which do not agree with those in the preceding report were presented by Van Demark et al. (1960). In this study, Holstein bulls were fed 60 and 100 per cent of the TDN levels recommended by Morrison. At 36, 40, and 44 months of age, the underfed bulls produced 77 per cent as much sperm as the controls. From 40 to 58 months of age the rations were reversed. The original underfed bulls averaged only 79 per cent of the number of sperm cells which were produced by the controls that were at the time on the 60 per cent ration.

In his review article Reid (1960) reported, "The body weight of bulls on the low plane ranged from 61 to 68 per cent of that of bulls on

the high plane, the testicular volume and spermatozoa production by the low-level bulls ranged from 63 to 71 per cent and 45 to 57 per cent, respectively. These figures indicate that spermatogenesis suffers more than body size as the result of restricted feeding." In this same study it is suggested that semen production is positively correlated with the body size of bulls during the first two years of life. This observation was also reported earlier by Baker et al. (1955), and the correlation was found to be statistically significant. Reid (1960) further pointed out that a 20 per cent reduction in the body weight of adult bulls resulting from a reduced feed intake caused a 40 per cent reduction in semen output.

In a study ^{Smith} recently completed at the Pennsylvania State University, ^{by} Flipse and Almquist (1961) assigned new-born Holstein bull calves to four levels of energy intake representing 70, 100, 115, and 130 per cent of the National Research Council's recommended TDN allowances for growing dairy calves. The artificial vagina was used to collect semen samples from each bull at weekly intervals until live sperm cells were detected in the semen which was considered the onset of semen production. At this point collections were made at monthly intervals and data were collected on semen quantity and quality until the bulls reached 208 weeks of age. The average age at the onset of semen production was 61, 45, 41, and 44 weeks, respectively, for the 70, 100, 115, and 130 per cent groups. Comparable figures for body weight at the onset of semen production were 523, 643, 675, and 784 lb. At 80 weeks of age, the motile sperm output per ejaculate for the 70 per cent group was about

one-half that of the 130 per cent group. By 112 weeks of age, there was no significant difference in output of motile sperm per ejaculate associated with the level of energy intake. Between 156 and 208 weeks of age, the bulls on the highest energy level became much slower in sexual reaction time than bulls in other groups. During this same period, these high-level bulls exhibited increased weaknesses of the feet and legs. Depletion trials at four years of age confirmed the relatively low sexual response of the 130 per cent bulls. Sperm output and extra-gonadal sperm reserves were similar among all bull groups.

Effects of high-roughage rations. An early study of the effect of high-roughage rations on fertility of young bulls was conducted by Jones et al. (1945). Seven month old dairy bulls, maintained on a basal ration of good quality alfalfa hay, produced good quality semen at 18 months of age; however, bulls that were fed the basal ration plus a pound of supplement daily produced acceptable semen at 12 months of age. Both groups of bulls remained fertile between 2 and 2½ years of age while in service. This early maturity in the supplement-fed bulls was believed to be due to the fact that the bulls consumed greater amounts of energy rather than increased amounts of protein or any improvement in quality of protein.

The effect of large amounts of grass silage on the fertility of bulls has been studied by Flipse et al. (1952). Bulls were paired and one bull of each pair received 4 lb. of grass silage per 100 lb. of body weight daily; the other bull received an equal amount of TDN in the form of concentrates. Semen quantity and quality tests were conducted on a

weekly basis and showed no statistically significant differences in semen production in the two groups. Later, Flipse and Almquist (1957) continued feeding bulls large quantities of grass silage for extended periods of time. While being maintained in a bull stud, bulls fed on a high grass silage ration for two years had 30,845 first services as opposed to 36,025 for control bulls in the same stud. The 180-day nonreturn rate was 66.2 and 66.6 per cent for the silage and control groups, respectively. Eighteen pairs of bulls similarly tested for a one-year period had 40,833 and 43,839 first services, and 180-day nonreturn rates of 64.9 and 65.3 per cent for the silage and control groups, respectively. As a result of this work, the authors concluded that the all-roughage ration maintained bulls in good condition throughout the two-year period and semen quality was not affected.

Flipse (1957) reported no difference in growth, attainment of sexual maturity, or quantity and quality of semen in bulls fed a ration of corn silage and hay compared with bulls fed concentrates and hay. However, blood urea and non-protein nitrogen tended to be lower in the silage-fed group than in the control group, possibly as a result of lower protein intake on the silage ration.

CHAPTER III

EXPERIMENTAL PROCEDURE

This experiment was designed to test the performance of bulls under various nutritional conditions. The test was divided into winter, pasture, and full-feed periods; performance was measured by daily gain, change in type and condition grades, cost of gain, total cost per head, feed efficiency, and lifetime average daily gain to the end of the test. A semen sample from each bull was collected and evaluated at the end of each of the three periods.

One group of 20 Angus and Hereford bulls has completed all three periods (1961-62), while another group has only completed the winter period (1962-63).

Source of Bulls

With the exception of one bull, all bulls were bred and born in the University of Tennessee Experiment Station herds; one Angus bull was purchased from a private herd. Calves with an adjusted average daily gain of 1.80 lb. or higher and a type grade of 12.0 or greater at weaning were the only bull calves selected for the experiment. If a calf had had access to creep feed or a nurse cow, he was not used in the test.

Pre-test Management

Shortly after weaning, the bulls were hauled by truck to the main station at Knoxville. Upon arrival each calf was injected intramuscularly

with 4 to 6 cubic centimeters of a tranquilizing agent and a capsule containing 1 ounce of chlortetracycline was administered orally. The feeding trials were not initiated for approximately two weeks to allow the calves to be assembled from all locations, to have ample time to recover from any effects of shipping, and to become accustomed to feed. During this period the bulls were provided with a ration which consisted of 40 per cent concentrates and 60 per cent ground hay. Enough of the antibiotic was added so that each bull consumed approximately 300 milligrams daily the first three days and 75 milligrams each day for the remainder of the period. The average daily consumption for each bull was between 12 and 15 lb. of feed. Each bull was identified with a hip brand, vaccinated for both blackleg and brucellosis, and Herefords were dehorned during this interim. Prior to November first (the beginning day for the winter period of the test), the bulls were weighed on two consecutive days and divided into uniform lots as to weight, grade, source, sire, and breed--breeds were integrated in each lot for the first year, but not for the second year--; these lots were then randomly assigned to either a B or C treatment.

Winter Period

Housing. The ground floor of a barn similar in structure to a "bank" barn was converted into pens, 12 feet by 24 feet. This made space for exercise lots unavailable. Each pen was provided with a mineral box and a concrete watering trough. Even though the barn had a southeasterly exposure, the interior pens were practically void of sunlight during the winter. A lot consisting of five bulls was confined to

each pen for the 140-day duration of the test with the exception of weigh days at which time they were moved a distance of 250 yards to another barn for weighing and then returned to their respective pens.

Treatments. Treatment B consisted of 4 lb. of cracked, shelled, yellow corn, 1.5 lb. of cottonseed meal (41 per cent protein), 2 lb. of alfalfa hay, 75 milligrams of antibiotic per head per day, and corn silage according to appetite. Treatment C was identical to that of treatment B except that 1 lb. of corn was provided instead of 4 lb.

Feed. The silage was produced from corn grown locally and was ensilaged at the pre-dent stage of maturity. Unfortunately, the roof of the up-right silo had blown off; thus, the moisture content of the silage varied with the elements throughout this period. A chemical analysis of the silage appears in Table I. The hay was purchased locally and was of good quality alfalfa occasionally mixed with small amounts of grass. The cottonseed meal, salt, and dicalcium phosphate were purchased at a local mill. The corn was trucked from the cornbelt.

Management. The bulls were fed silage and concentrates twice a day and hay once a day.

At the 6:00 a.m. feeding, the silage was fed first and one-half the daily allotment of concentrates was sprinkled over the top of it. At the 4:00 p.m. feeding, any silage which was not consumed was weighed and discarded, fresh silage was provided, and the remainder of the concentrates was fed. After the bulls had had ample time to consume the concentrates (a period of approximately 20 minutes), hay was provided.

TABLE I
CHEMICAL ANALYSIS OF CORN SILAGE

	Fresh Basis %	Air-Dry Basis %	Dry Basis %
Moisture	73.00	4.00	--
Ash	0.80	2.98	3.10
Crude fiber	6.21	23.59	23.99
Ether extract	0.72	2.67	2.79
Nitrogen free extract	15.15	56.11	58.45
Protein	2.10	7.79	8.10

The bulls were sprayed for lice at the termination of the first and third 28-day weigh periods. At the conclusion of the winter period, the bulls were weighed on two consecutive days and graded for type and condition by two members of the Animal Husbandry-Veterinary Science Department.

The Interim between Periods

At the conclusion of the winter period all bulls were permitted to consume the B level of concentrates; however, the amount of roughage consumed was limited to 25 lb. to facilitate the following practices during this 10-day period.

1. Halter breaking
2. Feet trimming
3. Semen collection

The finger-ring method of electroejaculation (as described by Parish, 1958) was used to collect one semen sample from each bull. The samples were subjectively evaluated by two members of the Animal Husbandry-Veterinary Science staff on the basis of volume and color of the ejaculate and number and per cent motility of sperm cells.

Pasture Period

On April first all bulls were weighed once and divided into two groups according to the level of feeding during the winter period. These two groups, "B's" and "C's," were turned out on separate pastures consisting of orchardgrass, ladino clover, and alfalfa.

While on pasture, each group was fed to provide each bull 8 lb. of a mixture of 90 per cent cracked corn and 10 per cent cottonseed meal daily. The pasture treatment that provided limited grain was designated as A by Anderson (1962) as opposed to no grain on pasture, treatment B. This arrangement resulted in two treatment groups:

BA - Full-feed of silage, 5.5 lb. of concentrates, and 2 lb. of alfalfa hay per animal daily in the winter and limited amounts of grain on pasture.

CA - Full-feed of silage, 2.5 lb. of concentrates, and 2 lb. of alfalfa hay per animal daily in the winter and limited amounts of grain on pasture.

During this period all bulls had access to fresh water, dicalcium phosphate, and salt. The bulls were sprayed for flies at the conclusion of the first and third 28-day weigh periods.

At the end of the pasture period, the bulls were weighed on two consecutive days and graded for type and condition by two members of the Animal Husbandry-Veterinary Science Department. At the termination of this period, each bull was haltered, a semen sample was collected and evaluated, and feet were trimmed.

Full-feed Period

Housing. At this point each treatment group of bulls was placed in pens on opposite sides of a barn that simulated a loafing shed. Each pen was provided with a mineral box, a concrete watering trough, and enough feed-bunk space to enable all bulls to eat simultaneously. A half-acre exercise lot was connected to each pen.

Ration. A mixed ration of 25 per cent ground hay, 63 per cent cracked, shelled, yellow corn, 8 per cent cottonseed meal, 3 per cent molasses, 0.5 per cent salt, and 0.5 per cent dicalcium phosphate (percentages are by weight) was provided to the bulls according to appetite. The molasses used during this period was purchased from a local distributor. The other sources of these feeds were the same as described earlier.

Management. In order to gradually start the bulls on feed and to prevent any detrimental effects from sudden increase in energy intake, the hay was increased to 60 per cent and the concentrates decreased to 40 per cent at the onset of this period. During the first three weeks the ration was gradually re-adjusted to the desired percentages stated in the previous section.

Fresh feed was provided at 7:00 a.m. and 5:00 p.m. throughout the full-feed period. Twice weekly, all feed was removed from the bunks, weighed, and discarded.

At the end of this test the bulls were weighed on two consecutive days and graded for type and condition by two members of the Animal Husbandry-Veterinary Science Department. A semen sample was collected from each bull.

Methods of Analysis

Throughout the test accurate records were compiled on feed consumption, feed cost, feed utilization, daily gains, change in type and condition grades, and semen quality. The feed prices that were used

to compute cost per pound of gain and total cost per bull are presented in Table II. Treatment differences in rate of gain, type grade, condition grade, and semen quality were evaluated statistically using analysis of variance and Duncan's Multiple Range Test.

The mean square for bulls within a lot was used to test the significance of differences between lots treated alike; the mean square for lots treated alike was used as the error term for testing the significance of treatment differences during the winter period. Since limited facilities prohibited the replication of treatments during the pasture and full-feed periods, the mean square for individual animals was used as the error term.

Data for the two years of the winter period were pooled and the mean square for lots within treatments within years was used as an error term for testing the significance of treatment differences, year differences, and year x treatment interaction. The semen data for the three periods of the 1961-62 bulls were pooled and the mean square for bulls was used to test for treatment x period interaction. Since there was a significant interaction, the treatment x period mean square was used to test the significance of period and treatment differences.

Analysis of variance tests were applied to feed cost per 100 lb. of gain during the winter period. Lack of duplication of lots prevented such analysis of the pasture and full-feed periods.

TABLE II
FEED PRICES USED TO COMPUTE FEED COSTS

Ingredient	Price/Unit
Corn silage	\$ 8.00/ton
Cottonseed meal	70.00/ton
Dicalcium phosphate	80.00/ton
Ground shelled corn	1.37/bushel
Hay (all)	34.00/ton
Molasses	33.00/ton
Pasture	.07/animal day
Salt	31.00/ton

CHAPTER IV

RESULTS AND DISCUSSION

Winter Period

The B treatment ration during the winter period consisted of 4 lb. of cracked, shelled, yellow corn, 1.5 lb. of cottonseed meal, 2 lb. of alfalfa hay, and 75 mg. of antibiotic per head per day and corn silage according to appetite; whereas, the C treatment ration was identical to that of treatment B except that 1 lb. of corn was provided instead of 4 lb. The performance record of each group of bulls completing this period of the test is summarized in Table III.

Average daily gain. The difference between treatments B and C in average daily gain for both years was comparable--0.30 lb. for 1961-62 and 0.33 lb. for 1962-63. The bulls on treatment B during 1961-62 gained 2.08 lb.; whereas, the bulls on the same treatment in 1962-63 gained 2.15 lb. The bulls on treatment C in 1961-62 gained 1.78 lb. as compared to 1.82 lb. for their counterparts in 1962-63. The treatment difference for 1961-62 was statistically significant ($P < .05$); however, the 1962-63 treatment difference was not statistically significant even though the difference was greater. This is attributed to the fact that during the second year there was more variation between lots within a treatment than there was between treatments.

Table IV shows the analysis of variance of the pooled data on daily gain for the two years. Because of the relatively small number

TABLE III
PERFORMANCE OF BULLS DURING THE WINTER PERIOD

Year Treatment	1961-62		1962-63		Average 1961-62, 62-63	
	B	C	B	C	B	C
No. animals/lot	5	5	5	5	5	5
No. animals/treatment	10	10	10	10	20	20
No. days on test	140	140	124	124	132	132
Av. wt. and gain/head, lb.						
Initial wt.	547	554	596	606	572	580
Final wt.	838	804	863	832	850	818
Total gain	292	250	267	226	278	238
Daily gain	2.08	1.78	2.15	1.82	2.12	1.80
Av. daily ration, lb.						
Hay	1.75	1.79	1.86	1.92	1.80	1.86
Corn	4.00	1.00	4.00 ³⁷⁸⁷	1.00	4.00	1.00
Corn silage	29.49	33.54	30.54	36.16	30.02	34.85
Cottonseed meal	1.50	1.50	1.50	1.50	1.50	1.50
Antibiotic (mg.)	75.00	75.00	--	--	--	--
Salt	0.06	0.08	0.07	0.07	0.07	0.08
Dicalcium phosphate	0.04	0.03	0.02	0.03	0.03	0.03

4128.6

1413.90

2701%

2704%

TABLE III (CONTINUED)

Year Treatment	1961-62		1962-63		Average 1961-62, 62-63	
	B	C	B	C	B	C
Air-dry feed required/cwt. gain, lb.						
Hay	82.1	99.0	86.7	105.2	84.4	102.1
Corn	191.8	56.0	186.1	54.8	188.9	55.4
Corn silage	381.9	507.1	383.5	533.4	382.7	520.2
Cottonseed meal	71.9	84.0	69.8	82.2	70.8	83.1
Salt	4.0	5.1	3.7	4.1	3.7	4.6
Dicalcium phosphate	2.1	2.6	1.0	1.7	1.6	2.2
Total	733.8	753.8	730.8	781.4	732.1	767.6
Feed cost/head	\$42.75	\$35.16	\$37.90	\$31.84	\$40.32	\$33.50
Feed cost/lb. gain	14.6¢	14.1¢	14.2¢	14.1¢	14.4¢	14.1¢
Grades						
Initial type	13.2	13.2	12.8	13.0	13.0	13.1
Final type	13.1	12.5	12.8	12.6	13.0	12.6
Initial condition	9.8	9.7	9.0	9.3	9.4	9.5
Final condition	8.8	7.8	9.5	9.5	9.2	8.6

TABLE IV
ANALYSIS OF VARIANCE OF COMBINED 1961-62, 1962-63 WINTER GAINS

Source of Variation	Degrees of Freedom	Mean Square
Treatments	1	0.9766*
Years	1	0.0265
Y x T	1	0.0016
Lots (Y - T)	4	0.2038*
Bulls (lots- Y - T)	32	0.0838

*P < .10

of bulls on each treatment, the treatment difference for the two years combined only approached statistical significance at the 10 per cent probability level. However, in an era of feed additives in which nutritionists are striving to improve daily gain by as little as 0.1 lb., a treatment difference of 0.3 lb. is of practical significance.

The gains made during 1962-63 were higher than those made in 1961-62. The fact that the bulls in the 1962-63 group averaged approximately 50 lb. more at the beginning of the experiment than those in the preceding year may have given them the ability to make better use of roughages.

The average daily gain made by the bulls on the B treatment was 0.1 to 0.2 lb. higher than those reported by Anderson (1962) for bulls on the same treatment, yet these gains were almost identical to those reported by McCampbell et al. (1929a and 1929b) when a similar ration was fed to weanling steer calves.

Feed consumption and costs. Since the bulls on the C treatment were limited to 1 lb. of shelled corn per day, compared with 4 lb. for those on the B treatment, they consumed an average of 4.83 lb. more silage per day than the bulls on the B treatment. Nevertheless, bulls on the B treatment actually consumed 1.65 lb. more dry matter per day than those on the C treatment. A higher percentage of the feed consumed by the bulls on the B treatment was concentrate; therefore the average daily feed costs were 31 cents as compared to 26 cents for the bulls on treatment C. This difference was statistically significant ($P < .005$)

as shown in Table V. Because the bulls on the C treatment consumed small amounts of high-energy feeds, the difference in feed required per 100 lb. of gain was 36 lb. more than the feed requirement for the bulls on the B treatment. When the actual feed costs were calculated on a cost per pound basis, the average was 14.4 cents for the bulls on the B treatment compared to 14.1 cents for those on the C treatment.

Type grades. A grading system in which the numbers 14, 13, and 12 have been designated as high, average, and low choice, respectively, was used to measure changes in type grades of the bulls throughout this study. At the end of the 1961-62 winter period, the average type grade of the bulls on the B treatment was 13.1 compared to 12.5 for the bulls on the C treatment; the difference approached statistical significance at the 10 per cent probability level. During the second year the average grade for the bulls on the B treatment was 12.8 versus 12.6 for the bulls on the C treatment; this difference was not statistically significant. Table VI shows that there was a statistically significant difference ($P < .05$) between the two-year grade averages of 13.0 for the bulls on the B treatment and 12.6 for those on the C treatment. Tables VII and VIII show a highly significant treatment difference ($P < .025$) in the change of type grade from weaning to the end of the winter period during the first year of this experiment; however, the differences between the treatments the second year and for the two years combined were not statistically significant.

TABLE V

ANALYSIS OF VARIANCE OF COST PER DAY DURING THE WINTER PERIOD
1961-62, 1962-63 COMBINED

Source of Variation	Degrees of Freedom	Mean Square
Treatments	1	0.5000**
Years	1	0.0000
Y x T	1	0.0100
Lots (Y - T)	4	0.0125

**P < .005

TABLE VI
ANALYSIS OF VARIANCE OF COMBINED 1961-62, 1962-63 TYPE GRADES

Source of Variation	Degrees of Freedom	Mean Square
Treatment	1	1.220*
Year	1	0.020
Y x T	1	0.410
Lots (Y - T)	4	0.188
Bulls (lots- Y - T)	32	0.566

*P < .05

TABLE VII

ANALYSIS OF VARIANCE OF CHANGE IN TYPE GRADE FROM WEANING TO THE
END OF THE WINTER PERIOD 1961-62, 1962-63

Source of Variance	Degrees of Freedom	Mean Square	
		1961-62	1962-63
Treatments	1	1.250*	0.450
Lots	2	0.025	0.850
Bulls	16	0.781	0.569

*P < .025

TABLE VIII

ANALYSIS OF VARIANCE OF POOLED CHANGE IN TYPE GRADE FROM WEANING
TO THE END OF THE WINTER PERIOD

Source of Variation	Degrees of Freedom	Mean Square
Treatments	1	0.220
Years	1	1.590
Y x T	1	0.110
Lots (Y - T)	4	0.438
Bulls (lots- Y - T)	32	0.675

Condition grades. The same system that was used to evaluate the type grades of the bulls was used to score their condition. Condition grades are lower than type grades; therefore the numbers 11, 10, and 9 represent high, average, and low good and 8, 7, and 6 represent high, average, and low standard, respectively.

The difference of one-third of a grade--8.8 for bulls on the B treatment versus 7.8 for those on the C treatment--during the first year of the experiment was statistically significant ($P < .05$). Bulls on both treatments during the second year had an identical average condition grade of 9.5. The fact that the bulls in 1962-63 averaged 50 lb. per head more at weaning than the bulls the year before may account for the difference in condition grade at the end of this period. Table IX shows that for the two years combined the difference of 0.8 of one-third of a grade was significant ($P = .05$), and that the year had more effect on the condition of the bulls than the treatment ($P < .005$).

Pasture Period

As previously stated, only the bulls tested in 1961-62 have completed all three periods of the experiment. The pasture treatment that provided 8 lb. of concentrates daily for each bull was designated as pasture treatment A. Since all bulls on the experiment were on this treatment during the pasture period, the winter B treatment became pasture treatment BA and the winter C treatment became pasture treatment CA. The performance of the bulls that completed this period (1961-62) is shown in Table X. The results of the statistical analysis of these data are given in Table XI.

TABLE IX

ANALYSIS OF VARIANCE OF COMBINED 1961-62, 1962-63 TYPE GRADES
AT THE END OF THE WINTER PERIOD

Source of Variance	Degrees of Freedom	Mean Square
Treatments	1	2.65*
Years	1	13.81**
Y x T	1	1.85
Lots (Y - T)	4	0.21
Bulls (lots- Y - T)	32	0.51

*P = .05

**P < .005

TABLE X
PERFORMANCE OF BULLS DURING THE PASTURE PERIOD

Year Treatment	1961-62	
	BA	CA
No. animals/lot	10	10
No. animals/treatment	10	10
No. days on test	101	101
Av. wt. and gain/head, lb.		
Initial wt.	838	804
Final wt.	950	936
Total gain	113	132
Daily gain	<u>1.12</u>	<u>1.31</u>
Av. daily ration, lb.		
Hay	0.57	0.53
Corn	6.91	6.82
Corn silage	1.27	1.27
Cottonseed meal	0.88	0.88
Salt	0.03	0.03
Dicalcium phosphate	0.03	0.03
Molasses	0.02	0.02
Feed required/cwt. gain, lb.		
Hay	51.1	40.4
Corn	617.6	520.0
Corn silage ^a	30.6	26.1
Cottonseed meal	78.6	66.3
Salt	2.4	2.6
Dicalcium phosphate	2.4	2.2
Molasses	2.2	1.7
Total ^b	<u>784.9</u>	<u>674.6</u>
Feed cost/head ^c	\$28.72	\$28.10
Feed cost/lb. gain ^c	26¢	21¢
Grades		
Initial type	13.1	12.5
Final type	12.9	12.4
Initial condition	8.8	7.8
Final condition	8.7	8.3

^aAir-dry basis.

^bExclusive of pasture.

^cIncludes 7 cents per animal day for pasture.

TABLE XI

ANALYSIS OF VARIANCE OF PERFORMANCE DURING THE PASTURE PERIOD

Source of Variation	Degrees of Freedom	Mean Square		
		Daily Gain	Type Grade	Condition Grade
Treatments	1	0.1767	1.51	1.010
Bulls	18	0.1290	0.61	0.457

Average daily gain. The bulls on the CA treatment had an average daily gain of 1.31 lb. as compared to 1.12 lb. for those on treatment BA. The difference between the two treatments was not statistically significant. The gains by the bulls on the BA treatment in this experiment were somewhat lower than those reported by Anderson (1962) for comparable bulls on a similar treatment. An extremely dry season at the beginning of the 1961-62 pasture period could have caused this difference in daily gain.

At the conclusion of both the winter and pasture periods, the bulls on the BA treatment had gained an average of 23 lb. more than the bulls on the CA treatment. According to the theory stated by Castle et al. (1961), the gain made by the two treatment groups of bulls would have been expected to be equal because of compensatory gain made by the bulls on the CA treatment during the pasture period. Dry weather at the beginning of the pasture period may have been a contributing factor to the failure of the CA treatment bulls to fully compensate on pasture for their lower gains during the winter period.

Feed consumption and cost. The feed consumption for both treatment groups was identical while they were actually on pasture. In order to obtain accurate cost records on the bulls throughout the test, feed that was consumed in the interim periods immediately following the winter period and just prior to the full-feed period was recorded in the pasture summary.

The actual costs per pound of gain from the time the bulls were taken off the winter period until they were started on the full-feed period was 26 cents for the bulls on treatment BA and 21 cents for the ones on treatment CA. These costs include a pasture charge of 7 cents per animal day.

Type grades. There was very little change in the average type grades of the bulls between the end of the winter period and the end of the pasture period. The bulls on the BA treatment had an average grade of 12.9 while the average grade for the bulls on the CA treatment was 12.4. The difference between the two treatment groups was not statistically significant.

Condition grades. The difference between the average condition grade of 8.7 for the bulls on the BA treatment and 8.2 for the bulls on the CA treatment was not statistically significant.

Full-feed Period

Following the pasture period, the bulls were moved to a barn and fed a ration that consisted of 75 per cent concentrates and 24 per cent ground hay according to appetite. Tables XII and XIII show the performance of the bulls during this period and the statistical analysis of the data, respectively.

Average daily gain. The bulls that had been on the BA treatment gained 2.52 lb. as compared to 2.40 lb. for those on the CA treatment. The difference between these averages was not statistically significant.

TABLE XII

PERFORMANCE OF BULLS DURING THE FULL-FEED PERIOD

Year Treatment	1961-62	
	BA	CA
No. animals/lot	10	10
No. animals/treatment	10	10
No. days on test	99	99
Av. wt. and gain/head, lb.		
Initial wt.	950	936
Final wt.	1200	1174
Total gain	250	238
Daily gain	<u>2.52</u>	<u>2.40</u>
Av. daily ration, lb.		
Hay	7.43	7.20
Corn	17.60	16.90
Cottonseed meal	2.29	2.20
Salt	0.14	0.14
Dicalcium phosphate	0.14	0.14
Molasses	1.04	1.00
Feed required/cwt. gain, lb.		
Hay	294.0	299.0
Corn	696.9	703.9
Cottonseed meal	90.7	91.8
Salt	5.5	5.7
Dicalcium phosphate	5.5	5.7
Molasses	41.2	41.7
Total	<u>1133.8</u>	<u>1147.8</u>
Feed cost/head	\$65.72	\$63.11
Feed cost/lb. gain	26.5¢	26.6¢
Grades		
Initial type	12.9	12.4
Final type	13.6	13.0
Initial condition	8.7	8.3
Final condition	10.4	9.9

TABLE XIII

ANALYSIS OF VARIANCE OF PERFORMANCE DURING THE FULL-FEED PERIOD

Source of Variation	Degrees of Freedom	Mean Square		
		Daily Gain	Type Grade	Condition Grade
Treatments	1	0.0871	2.110	1.510
Bulls	18	0.1505	0.785	1.160

For some unexplainable reason, one of the bulls on the CA treatment bloated quite frequently during the full-feed period. As a result, his average daily gain was a full pound less than the average for the other nine bulls on the CA treatment. If the performance of this one bull is not considered in the final average, the bulls on the CA treatment gained an average of 2.51 lb. daily compared to 2.52 lb. for those on the BA treatment.

Feed consumption and cost. The bulls on the BA treatment consumed slightly more feed than those on the CA treatment; however, since the bulls on the CA treatment gained less weight, the cost per pound for both treatment groups during this period was virtually the same--- 26.5 cents for the bulls on the BA treatment and 26.6 cents for the bulls on the CA treatment.

Type grades. The average type grade at the end of the full-feed period was 13.6 and 12.9 for the bulls that had been on treatments BA and CA, respectively. The difference between the two treatments was not statistically significant.

Condition grades. There was no statistical difference between the average condition grades of 10.4 for bulls on the BA treatment and 9.9 for the bulls on the CA treatment.

The Three Periods Combined

Table XIV is a summary of the performance of the bulls for the three periods combined. The bulls that had been on the BA treatment had

TABLE XIV

SUMMARY OF BULLS' PERFORMANCE FOR THE THREE PERIODS COMBINED

Year Treatment	1961-62	
	BA	CA
No. of animals	10	10
Daily gain, lb.		
Winter	2.08	1.78
Pasture	1.12	1.31
Full-feed	2.53	2.40
3 periods	<u>1.92</u>	<u>1.82</u>
Av. initial weight, lb.	547	554
Av. final weight, lb.	1200	1174
Type grades		
Initial	13.2	13.2
End of winter	13.1	12.5
End of pasture	12.9	12.4
End of full-feed	13.6	12.9
Condition grades		
Initial	9.8	9.7
End of winter	8.8	7.8
End of pasture	8.7	8.2
End of full-feed	10.4	9.9
Feed cost/head		
Winter	\$ 43.33	\$ 35.16
Pasture	\$ 28.72	\$ 28.10
Full-feed	\$ 65.72	\$ 63.11
Total for 3 periods	<u>\$137.77</u>	<u>\$126.37</u>
Cost/lb. gain		
Winter	14.6¢	14.1¢
Pasture	26.0¢	21.0¢
Full-feed	26.5¢	26.6¢
Feed cost/cwt. gain	\$ 21.50	\$ 20.38
Total feed cost/bull	\$137.77	\$126.37
Initial cost/bull	\$250.00	\$250.00
Total cost	\$387.77	\$376.37

gained an average of 1.91 lb. daily as compared to 1.83 lb. for the bulls on treatment CA. Table XV shows that the difference between the treatments was not statistically significant. On a lifetime basis, the bulls on treatment BA had an average daily gain of 2.08 lb.; whereas, the bulls on the CA treatment had gained 1.89 lb. daily.

The total feed cost per bull was \$137.77 and \$126.37 for bulls on treatments BA and CA, respectively.

Fertility

The number of sperm cells per ejaculate and the percentage of these cells that were motile were the two parameters used to evaluate the fertility of the bulls. Tables XVI and XVII show the results of these studies.

There was a statistically significant difference ($P < .05$) in the per cent motility of sperm cells between the bulls on treatments B and C at the end of the winter period of 1961-62. However, this difference did not exist in the 1962-63 bulls. When the two years' data were pooled, there was no significant difference between the two treatment groups as shown in Table XVIII.

It was found that there was no statistical difference in the per cent motility of sperm cells between the two treatment groups at the end of the pasture period nor at the end of the full-feed period for the 1961-62 group of bulls.

Statistical analyses were made on the data that had been accumulated on the number of sperm cells produced per ejaculate. It was found

TABLE XV

ANALYSIS OF VARIANCE OF GAINS FOR THE THREE PERIODS COMBINED

Source of Variation	Degrees of Freedom	Mean Square
Treatments	1	0.0345
Bulls	18	0.0211

TABLE XVI
SUMMARY OF SEMEN EVALUATION FOR WINTER PERIODS

Year Treatment	1961-62		1962-63		Average 1961-62, 1962-63	
	B	C	B	C	B	C
Motility (%)	58.0	40.0	52.6	48.5	55.3	44.2
Number/ejaculate (billion)	3.50	2.08	3.31	5.12	3.40	3.60

TABLE XVII

SUMMARY OF SEMEN EVALUATION FOR THE THREE PERIODS COMBINED

Year Treatment	1961-62	
	BA	CA
Winter period		
Motility (%)	58.0	40.0
Number (billion)	3.50	2.08
Pasture period		
Motility (%)	75.0	73.5
Number (billion)	6.70	6.90
Full-feed period		
Motility (%)	58.5	65.0
Number (billion)	3.47	3.08

TABLE XVIII
ANALYSIS OF VARIANCE OF POOLED WINTER DATA ON SPERM MOTILITY

Source of Variation	Degrees of Freedom	Mean Square
Treatments	1	1221
Years	1	24
Years x treatments	1	483
Lots (Y - T)	4	664
Bulls (lots- Y - T)	32	621

that there was no statistical difference between treatment groups at any of the times semen was collected. However, there was a great deal of variation between individual bulls on the same treatment.

Although there was no statistical difference in the percentage of motility or the sperm cell concentration between periods, it is noted that the values of these parameters decreased markedly during the full-feed periods. This decrease in semen quality when the bulls were consuming high-energy rations was also noted by Flipse and Almquist (1961).

CHAPTER V

SUMMARY

An experiment was designed to compare different amounts of roughage that can be incorporated into a ration for testing the productive ability of developing beef bulls. In order to test the productive ability of the bulls under different nutritional conditions, a test that consisted of winter, pasture, and full-feed periods was used.

The treatments tested were:

BA - Full-feed of silage, 5.5 lb. of concentrates, and 2 lb. of alfalfa hay during the winter, and limited amounts of grain on pasture and a full-feed of concentrates in the feed lot.

CA - Full-feed of silage, 2.5 lb. of concentrates, and 2 lb. of alfalfa hay during the winter, and limited amounts of grain on pasture and full-feed of concentrates in the feed lot.

Twenty Angus and Hereford bulls have completed all three periods while a similar group has completed the winter period only.

During the winter period the bulls on the BA treatment gained 2.12 lb. per day as compared to 1.80 lb. for the bulls on the CA treatment. The bulls that were on the BA treatment carried slightly more condition than the ones on the CA treatment.

The bulls on the CA treatment had an average daily gain of 1.31 lb. as compared to 1.12 lb. for those on the BA treatment during the pasture period. The gains made by the bulls on the CA treatment

during the winter and pasture periods combined did not equal the gains made by the bulls on the BA treatment during these two periods. There was little difference in type or condition grades between treatment groups at the end of the pasture period.

The bulls on treatments BA and CA had an average daily gain of 2.53 lb. and 2.40 lb., respectively, during the full-feed period. The type and condition grades for all bulls at this point showed no statistical difference.

Throughout the three periods the bulls on the BA treatment had an average daily gain of 1.92 lb. as compared to 1.82 for the bulls on the CA treatment. Even though the lifetime average daily gain and type and condition grades were slightly higher for the bulls on the BA treatment, there was no statistical difference between treatment groups for the entire test period.

Because the bulls on the CA treatment consumed larger amounts of low-cost roughages, the cost per head was \$126.37 for the bulls on the CA treatment and \$137.77 for those on the BA treatment.

There was no significant effect on semen quality due to treatment.



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