8-1966

A comparison of systems of developing beef bulls to about twenty months of age

Thomas C. Snodgrass

To the Graduate Council:

I am submitting herewith a thesis written by Thomas C. Snodgrass entitled "A comparison of systems of developing beef bulls to about twenty months of age." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

C. S. Hobbs, Major Professor

We have read this thesis and recommend its acceptance:

H. J. Smith, James M. Anderson

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

August 9, 1966

To the Graduate Council:

I am submitting herewith a thesis written by Thomas C. Snodgrass entitled "A Comparison of Systems of Developing Beef Bulls to About Twenty Months of Age." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

Charles S. Hobbs
Major Professor

We have read this thesis and recommend its acceptance:

Harold J. Smith

James W. Anderson

Accepted for the Council:

Hilton A. Smith
Dean of the Graduate School

A COMPARISON OF SYSTEMS OF DEVELOPING BEEF BULLS TO ABOUT TWENTY MONTHS OF AGE

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

Thomas C. Snodgrass

August 1966

ACKNOWLEDGEMENT

The author is deeply indebted to the many persons who have willfully given their time and patience in the improvement of his personal development and to the composition of the foregoing Master's thesis. Special thanks are extended to the following persons:

To Dr. C. S. Hobbs, Major Professor, for his wise counsel and guidance throughout the course of graduate study and his careful reading of the manuscript.

To Dr. H. J. Smith for his genuine interest, encouragement and helpful suggestions.

To James M. Anderson for reading the manuscript and making many helpful suggestions.

To Bill Sanders and Will Butts for their assistance with the statistical analysis.

To the University of Tennessee Computing Center for the use of equipment in making the statistical computations.

To each undergraduate student, graduate student and farm worker who helped do much of the work required to collect the data herein presented.

TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

TABLE PAGE

CHAPTER I

INTRODUCTION

Performance testing is important in the beef cattle industry as an aid to selection for improvement. It is an excellent means for evaluating the genotypic and phenotypic worth of an animal. Since the sire transmits one-half of the genetic material of each calf, an estimate of the genetic potential of each sire should be made prior to selection if optimum genetic progress is to be accomplished.

Despite the need for choosing a herd sire with a reliable performance record, there is still little information in the literature relating to methods of developing beef breeding bulls. Most performance testing programs for beef bulls have been progeny tests. These are useful in predicting a bull's prepotency but are time consuming and expensive.

Most post-weaning performance tests for beef cattle have emphasized that the best way to evaluate the gaining and feed utilizing ability of an animal is to feed a maximum of concentrate for a period of 140 days or some similar period. This type of test has been used as one of the criteria for the selection of breeding stock.

Ruminant animals have the unique ability of converting low cost roughages, with the assistance of rumen microorganisms, into a wholesome, nutritious human food. Since roughages are a natural food for beef

cattle, it is more economical and practical to feed high levels of roughages to beef animals for development and maintenance. There may be times when high levels of concentrates are desirable, such as a finishing period for slaughter animals, yet this is only a short span in the lifetime of an animal.

To obtain more data on methods of developing bulls and considering the foregoing facts, a comparison of methods of developing bulls was initiated by the Animal Husbandry-Veterinary Science Department at the University of Tennessee. In an earlier report, Anderson (1962) concluded that the most desirable program of those tested for developing bulls was:

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 concentrate per head per day.

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

3. A 98-day full-feed period.

This was designated as the BA system of developing bulls.

In a later report, Knapka (1963) compared the BA system with one designated as the CA system. The CA system differed from the BA system only in that during the 140-day wintering period 2.5 lb. of concentrates were fed instead of 5.5 lb.

Throughout the three periods the bulls on the BA system had an average daily gain of 1.92 lb. as compared to 1.82 lb. for the bulls

on the CA system. The lifetime average daily gain, type grade and condition grade were slightly higher for the bulls on the BA system, but there was no significant difference between treatment groups for the entire test period. Because the bulls on the CA system obtained a greater percentage of their nutrients from less expensive roughages during the winter period, the feed cost per head was $11.40 less for the bulls on the CA system than for those on the BA system.

The main disadvantage of these two systems compared to a 140-day full-feed test is the higher feed, labor and handling cost resulting from the extended length of time on test. Also, there is some delay in obtaining the complete data on a bull, which could result in considerable retardation of genetic progress.

The objectives of this thesis are to compare bulls developed on the BA system with those developed on the CA system and to relate their performance from birth to weaning with their post-weaning performance.

CHAPTER II

REVIEW OF LITERATURE

I. METHODS OF EVALUATING BULLS

Beef cattle have been evaluated by visual appraisal since the time of Robert Bakewell. However, it has only been during the past 35 years that formal proposals have been made to record qualities that could be accurately measured to supplement visual appraisal.

Sheets (1932) offered a record of performance system based on the following factors:

1. An accurate record of the weight increase from birth.

2. A complete record of feed consumption to the end of the fattening period.

3. A slaughter score-card rating based on dressing percent and the physical and chemical analysis of the cooked meat.

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.

Following a critical review of the methods of measuring performance of beef cattle suggested by Holbert (1932) and Sheets (1932), Winters and McMahon (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.

Data accumulated from calves weaned at a constant age (252 days) and slaughtered at a constant weight (900 lb.) were used by Black and Knapp (1936) to calculate 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 sires production potential.

In a later paper, Black and Knapp (1938) gave experimental evidence comparing the proposals of Sheets (1932), Winters and McMahon (1933), and Black and Knapp (1936) for measuring the performance of beef cattle. They studied the data collected from 147 steers located at three stations. The method 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 the basis of progeny performance. They considered that the results obtained by using this method were influenced less by the dam's milk production than were the other methods.

Clark et al. (1943) collected data on weaning weight, feed lot gain, market weight, percentage of bloat, carcass grade, sale price and gross returns on 8 randomly selected steers by each of 11 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 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. After statistical analysis of the data, the authors concluded that the ability for rapid growth is highly heritable and that practically no relationship existed between type score and gain ($r = -.041$). Initial grade and final grade are highly correlated ($r = .724$).

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

Gregory et al. (1961) proposed a possible program for measuring post-weaning performance in bulls which would give final weights and grades at about the normal market age for a high percentage of slaughter cattle. This program would consist 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. During the following summer, the bulls would be fed a higher level of concentrates than during the preceding winter, either on grass or in dry lot. The reasoning behind this program is that bulls would be developed at a high enough level of feeding over a long 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 be combined and adjusted to a 550-day weight which could be used to measure growth rate of the bull. As an alternate 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 should be given an equal opportunity.

2. Systematic, written records be kept on all animals in a herd.

3. Adjust records for known sources of variation.

4. These records must be used in selecting replacement stock and in culling poor producers.

5. Nutritional programs and management factors must be practical and compatible with those where progeny of herd are expected to perform.

Rollins et al. (1962) performance tested 11 pair of Hereford bulls and performance tested from 8 to 10 steer progeny of each bull. Their objective was to calculate various performance criteria for selecting bulls on the basis of post-weaning growth made on a low concentrate high roughage ration. During a 4-month period from weaning to 12 months of age (referred to as the growing period) the bulls were fed a roughage ration of alfalfa hay. During cold, wet weather and when the hay was of poor quality, some grain was fed. During the next

4 months, the bulls were individually fed a fattening ration of 65 per cent concentrates. The steers were fed in the same manner as the bulls, but by sire groups.

On the growing ration, the average daily gain of bulls and steers averaged 1.5 lb. and 1.0 lb., respectively. On the fattening ration the bulls gained 2.6 lb. per day and the steers gained 2.5 lb. per day. The average daily total digestible nutrient consumption over maintenance requirements was 8.1 lb. for bulls and 9.2 lb. for steers.

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 concentrates and limited quantities of corn silage and alfalfa hay during the winter, limited amounts of concentrates on pasture.

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

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

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

The third phase of each system was a 98-day feed lot period in which bulls were fed concentrates and limited quantities of roughage. A total of 70 Angus and Hereford bulls completed post-weaning performance

tests in this experiment during 1959-60 and 1960-61. In addition to this, 33 Angus and Hereford bulls finished all periods of the AB and BB treatments in 1958-59.

During the winter period the bulls on the AA and AB treatments had an average daily gain of 2.29 lb. compared with 1.97 lb. for bulls on the BA and BB treatments. This difference was highly significant ($P < .01$). The average daily gain during the pasture period was 1.01 lb., 0.48 lb., 1.62 lb. and 0.82 lb. for bulls on treatment 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 interacton was reported. The average daily feed lot gains 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. There was a significant difference between the means of treatments AA and BB ($P < .01$). 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 ($P < .05$). They concluded that 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. Treatments had no marked effect on type grade. Condition grades were considerably higher at the end of the test for

bulls on treatments AA and BA than for bulls on treatments AB and BB.

The authors concluded that a system similar to that designated as BB was the most economical and that this treatment made the greatest use of roughages, but the bulls gained less on this system than on the other systems tested. They further concluded that, 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.

In a later report, Knapka (1963) designed an experiment to test the performance of bulls under various nutritional conditions. The test was divided into winter, pasture and full-feed periods.

The treatments tested were:

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

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

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

Throughout the three periods the bulls on the BA treatment had an average daily gain of 1.92 lb. compared to 1.82 lb. 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 feed cost per head was $126.37 for the bulls on the CA treatment and $137.77 for those on the BA treatment.

II. PRODUCTION PROGRAMS FOR SLAUGHTER CATTLE

In one of the earlier experiments, Good (1926) wintered 10 yearling steers on corn silage according to appetite, while 10 other steers were fed 5 to 6 lb. of corn per head per day with no silage. Both groups were fed the same amount of cottonseed meal and hay. After the winter period, the steers were placed on bluegrass pasture with no supplemental grain feeding. The combined winter and summer gains were 0.06 lb. per day greater for the steers receiving corn silage during the winter than for those that were fed corn. The cost per hundredweight of gain was $1.12 less for the steers fed silage during the winter than for those steers that received no silage.

McCampbell, Anderson and Alexander (1929a) reported an experiment in which 20 weanling steers were fed for 325 days on a three-phase program consisting of wintering, grazing and full-feeding phases. 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 gain for steers in Lot I and Lot II was 2.09 lb. and 1.55 lb., respectively. During

the 90-day grazing phase all steers grazed bluestem pasture. The daily gain was 0.85 lb. for steers in Lot I and 1.26 lb. for those in Lot II. While on the 100-day feed lot phase, in which all steers were fed on a similar ration, steers in Lot II gained 2.82 lb. and those in Lot I gained 2.53 lb. The total gain per steer over the entire 325 days was only 7 lb. greater for the steers receiving corn during the winter. The authors pointed out that, with the exception of the full-feeding 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, Anderson and Alexander (1929b). The only alteration was the increasing of the daily ration of corn for the Lot I steers during the winter from 4.66 lb. to 5.00 lb. The average daily gains during the winter and grazing phases were slightly higher for both lots in this second trial. In the feed lot phase, the daily gain was 2.86 lb. and 2.76 lb. for Lots I and II, respectively. The average daily gain for the 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 again made greater use of inexpensive roughages than the steers in Lot I.

Dyer (1952) fed 40 head of choice yearling steers on various feedstuffs through three distinct phases--wintering, grazing and full-feeding. 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 those 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. The cattle fed silage and hay during the winter took less time in the feed lot to reach a slaughter grade of choice than those that were maintained on blue grass pasture during the winter. The author stated that a management system which allows yearling steers as calves to gain 1.25 lb. to 1.50 lb. daily during the winter is most conducive for rapid feed-lot gains in Missouri.

Miller and Morrison (1953a) reported results of wintering calves with 2 lb. of corn (Lot III) versus wintering with no corn (Lot IV). A total of 60 steer calves were used over the 3 years of the experiment. Both lots received a daily ration of 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 while the steers in Lot IV gained 1.15 lb. per day. Lots III and IV were pastured together on the same pasture without grain for an average grazing season of 100-days. The average daily gain was 0.77 lb. and 1.04 lb. per day for the steers on Lots III and IV, respectively. 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, Miller and Morrison (1953b) stated there appeared to be no one plan for fattening steers, but that a feeding program

based on pasture should include as many of the following conditions as possible: purchase feeders in the fall, winter entirely or largely on good roughage, graze 100 days or more on a good pasture, feed enough grain either on pasture or in dry lot to produce good to choice slaughter cattle, and market from late September through December.

Duncan (1958) summarized 13 experiments involving over 300 head of yearling and 2-year-old steers. These experiments were conducted to determine the value of supplemental feeds, such as corn, cob and shuck meal and cottonseed meal, for fattening slaughter steers on pasture. Significantly greater gains were made by cattle on grass and grain compared to 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 wintering heavy weanling calves on low cost, high roughage rations, pasturing them during the summer without grain and finishing them in dry lot for 56 days.

Castle, Wallace and Bogart (1961) analyzed experimental data including winter gains, summer gains and winter feed consumptions on 184 calves over a 7-year period. On the basis of these data, the authors stated that rate of winter gain together with number of days on winter feed had a significant negative effect on subsequent summer gain. Total digestible nutrients required during the winter per 100 lb. of gain accumulated during both the winter and summer periods reached the minimum when animals gained 1.2 lb. per day during the winter. When both costs and returns were taken into account and an assumed cattle

price of $17.20 per hundredweight was used, the greatest return over feed costs occurred at 1.6 lb. of daily winter gain. Similar data have been presented by Kincaid, Litton and Hunt (1945), Mott and Miles (1946), Marion, Fisher and Jones (1956) and Heineman and Van Keuren (1956).

Weber, Bell and Pickett (1947) and Lohrding et al. (1959) found that low 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 concentrate feeding the sire groups were significantly more alike ($P < .05$) than would be expected by chance. On unlimited concentrate feeding the sire groups were significantly different ($P < .01$) from each other. They concluded that ad libitum feeding was the best method by which differences in ability to grow may be determined.

III. PRE-WEANING AND POST-WEANING PERFORMANCE

A considerable volume of data has been gathered to estimate the heritability values for important characteristics in beef cattle. Warwick (1958) summarized all studies known to be reported and obtained the following heritability percentage estimates: birth weight, 41; weaning weight, 30; post-weaning feed lot gain, 45; efficiency of feed lot gain, 39; and weaning grade, 16. Comparable estimates have been subsequently reported by Lasley and Day (1960) and Swiger (1961).

Brown and Gifford (1962) conducted a study to record certain genetic and environmental relationships among traits of beef cattle fed so that total feed consumption was limited by the intake of roughage. Records of 182 purebred Hereford and 256 purebred Angus bulls fed in record-of-performance test from 1953 through 1960 were studied. In a 154-day test, weaned bull calves were individually fed prairie hay to the limit of their appetite. Concentrate was adjusted to a ratio of two parts concentrate to one part hay. Heritability estimates were 0.46 for test gain, 0.76 for feed consumption, 0.80 for feed conversion, 0.58 for final type score and 0.85 for final feedlot weight. Genetic correlations were estimated as follows: between test gain and feed consumption, 0.394; test gain and feed conversion, -.344; test gain and final type score, 0.285; test gain and final weight, 0.307; feed consumption and feed conversion, 0.709; feed consumption and final type score, 0.780; feed consumption and final weight, 0.890; feed conversion and final type score, 0.481; feed conversion and final weight, 0.707; and final type score and final weight, 0.735.

Anderson (1962), in an experiment which was discussed earlier in this review, found the following correlations between daily gains in individual periods and lifetime average daily gain: actual daily gain birth to 120 days of age, 0.49 to 0.72; actual daily gain birth to weaning, 0.58 to 0.82; daily gain on pasture, -.021 to 0.49; and daily gain in feed lot, 0.33 to 0.83.

McDaniel (1965) conducted a study of the factors affecting beef bull performance to 2 years-of-age. Twenty-two performance traits of

185 selected bull calves were analyzed to determine (1) the effect of age-of-dam on pre-weaning, weaning and post-weaning traits, (2) the influence of calf age on pre-weaning, weaning and post-weaning traits, (3) the linear association among all traits and (4) if the presently used adjustments for age-of-dam affects an average daily gain at pre-weaning and weaning were appropriate for selected bull calves.

The author found that the effects of age-of-dam upon birth weight and average daily gain at weaning was highly significant ($P < .01$). Age-of-dam was also a significant source of variation on average daily gain from pre-weaning to weaning. The only post-weaning trait significantly influenced by age-of-dam was full-feed condition. In this study lifetime average daily gain was not influenced by age-of-dam. Age-of-calf variation was responsible for pronounced differences in pre-weaning type and condition and weaning type.

Post-weaning traits that were significantly influenced by age-of-calf were end of pasture type and end of full-feed condition. It seemed that average daily gain of bulls to 20 months of age was independent of age-of-calf. The relationship between weaning average daily gain and lifetime average daily gain was 0.48 and highly significant ($P < .01$).

CHAPTER III

EXPERIMENTAL PROCEDURE

I. SOURCE OF BULLS

The bulls were selected on a basis of weaning weight and grade from the University of Tennessee Experiment Station herds with the exception of one Angus bull which was purchased from a private herd. Calves with an adjusted average daily gain of 1.80 lb. or higher and a type grade of low choice or greater at weaning were the only ones selected for the experiment.

II. PRE-TEST MANAGEMENT

Shortly after weaning, on or around November 1, the bulls were hauled by truck to the Main Station at Knoxville. The feeding trials were not initiated for approximately two weeks so that calves assembled from all locations would have ample time to recover from the effects of shipping and become accustomed to feed. During this period the bulls were provided with a ration consisting of 40 percent concentrates and 60 percent ground hay. Each bull was identified with a hip brand and vaccinated for blackleg and brucellosis. At the end of this pre-test period, the bulls were weighed on two consecutive days and divided into uniform lots on the basis of weight, grade, source and breed. The lots were randomly assigned to either a BA or CA treatment.

III. WINTER PERIOD

Housing. For the years 1961-62 and 1962-63, the ground floor of a barn similar to a "bank" barn was converted into pens, 12 feet by 24 feet. For the years 1963-64 and 1964-65 a pole type barn was used. This barn was designed especially for cattle feeding and the pens measured 13 feet by 44 feet. Approximately one-half of each pen was under the roof of the barn and the other half was outside. The outside portion of the pen had a concrete floor which facilitated removal of manure from the pen.

A lot consisting of five bulls was confined to each pen for the 140-day duration of the test. The only time that they were removed from their lots was weigh days at which time they were driven to a central barn for weighing and then returned to their respective pens.

Treatments. The bulls on the BA treatment were fed a ration consisting of 4 lb. of cracked, shelled, yellow corn, 1.5 lb. of cottonseed meal (41 percent crude protein) 2 lb. of alfalfa hay and corn silage according to appetite. The CA treatment was fed identically to the BA treatment except that 1 lb. of corn was provided instead of 4 lb.

Feed. The silage was produced from corn grown locally. The hay was purchased locally and was good quality alfalfa occasionally mixed with orchardgrass. The cottonseed meal, salt and dicalcium phosphate were purchased from local feed suppliers. The shelled corn was trucked from the Indiana area of the cornbelt.

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

At the morning feeding, the silage was fed first and one-half the daily allotment of concentrates was spread over the top of it. At the afternoon 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 were given ample time to consume the concentrates (approximately 20 minutes), hay was provided.

The bulls were sprayed for lice during the winter period. At the conclusion of the 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 staff.

IV. THE INTERIM BETWEEN PERIODS

At the conclusion of the winter period all bulls were allowed to consume the BA level of concentrates. The daily ration of corn silage was limited to approximately 25 lb. to facilitate the following practices during this period of about 10 days.

1. Halter breaking.
2. Feet trimming.
3. Semen collecting and evaluating.

V. PASTURE PERIOD

In all years, except 1963-64, the bulls were divided into two groups according to the level of feeding during the winter period and

were turned out on separate pastures consisting primarily of orchardgrass and Ladino clover. In the summer of 1964 the bulls were turned out on the same pasture.

While on pasture bulls in each group were fed approximately 1 lb. of concentrate per 100 lb. of body weight. This concentrate mixture consisted of 8 parts cracked, shelled corn and 1 part cottonseed meal.

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 staff. At the termination of this period a semen sample was collected and evaluated from each bull. Also, each bull's feet were trimmed at the end of this period.

VI. FULL-FEED PERIOD

Each year at the end of the pasture period the bulls were full-fed for 98 days. During the years of 1961-62 and 1962-63 the bulls were housed in a barn with pens that simulated a loafing shed with a half acre exercise lot connected to each pen. During the years of 1963-64 and 1964-65 the bulls were replaced in the barn that housed them during the winter period. Only 3 to 4 bulls were placed in a pen. Each treatment group was fed separately so that their feed consumption could be measured.

The mixed ration for this period was as follows: (Percentages are by weight) 25.0 percent ground hay, 61.0 percent ground shelled corn, 8.0 percent cottonseed meal, 3.0 percent molasses, 2.0 percent animal fat, 0.5 percent salt and 0.5 percent dicalcium phosphate.

The animal fat was fed all years except 1961-62.

This ration was altered in order to start the bulls on feed gradually and to prevent any detrimental effects from sudden increases in energy intake. The percent hay was increased and the percent concentrates decreased at the onset of this period, then slowly re-adjusted to the above ration in about 2 to 3 weeks. All of these mixtures were self-fed.

At the end of the test the bulls were weighed on two consecutive days and graded by members of the Animal Husbandry-Veterinary Science Department staff.

VII. METHOD OF ANALYSIS

Throughout the test accurate records were compiled on feed consumption, feed cost, daily gains and type and condition grades. The feed prices that were used to compute cost per pound of gain and total cost per bull are presented in Table I.

Data for all years were pooled and treatment differences in rate of gain, type grade and condition grade were evaluated statistically using the method of least squares (Harvey, 1960). The mean squares for bulls within treatments were used as the error term for testing treatment differences. Breed and year effects were absorbed since variation was certain to exist by reason of these factors.

Correlations between 21 different factors used to measure both pre-weaning and post-weaning production ability were computed. Treatment, year and breed effects were absorbed to remove these sources of variation.

TABLE I

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/bu.
Hay (all)	34.00/ton
Molasses	33.00/ton
Pasture	0.07/animal day
Salt	31.00/ton
Animal fat	123.00/ton

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

CHAPTER IV

RESULTS AND DISCUSSION

I. WINTER PERIOD

The performance record of each group of bulls completing this phase of the test and the record for all years combined are summarized in Table II.

Average daily gain. The difference between treatments BA and CA was consistent for all years--0.31 lb. in 1961-62, 0.35 lb. in 1962-63, 0.37 lb. in 1963-64 and 0.25 lb. in 1964-65. The average daily gain of the bulls for all years for the BA and CA treatments were 2.22 lb. and 1.90 lb., respectively. This difference was highly significant ($P < .01$) as is shown in Table III.

Although the difference in gains were similar for each year, the average daily gain ranged from a high of 2.36 lb. and 1.99 lb. for BA and CA treatments, respectively, in 1963-64 to a low of 2.09 lb. and 1.78 lb. for BA and CA treatments, respectively, in 1961-62. The following may explain these differences in gains:

1. The average daily gain from birth to weaning for the years 1961-62 was higher than for other years. Therefore, the compensatory gains made during the winter period would probably have been less than those made by other bulls with lower gains to weaning.

2. The bulls during the years 1962-63 experienced more sickness

TABLE II

PERFORMANCE OF THE BULLS DURING THE WINTER PERIOD

Year	1961-62		1962-63		1963-64		1964-65		1961-64	
Treatment	BA	CA	BA	CA	BA	CA	BA	CA	BA	CA
No. animals	10	10	9[a]	10	10	10	10	9[a]	39	39
No. days on test	140	140	124	124	133	133	140	140	134	134
Av. wt. and gain/head, lb.										
Initial wt.	546	554	596	606	531	527	510	512	546	550
Final wt.	838	804	866	833	845	791	824	791	843	805
Total gain	292	250	270	226	314	264	314	279	297	255
Daily gain	2.09	1.78	2.17	1.82	2.36	1.99	2.24	1.99	2.22	1.90
Av. daily feed, lb.										
Hay (Alfalfa)	1.75	1.79	1.86	1.92	1.98	1.98	2.00	2.00	1.90	1.92
Gr. shelled corn	4.00	1.00	4.00	1.00	4.00	1.00	4.00	1.00	4.00	1.00
Corn silage	29.49	33.54	30.54	36.16	26.51	29.46	24.87	28.98	27.85	32.04
Cottonseed meal	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Salt and dical.	0.10	0.11	0.09	0.10	0.09	0.08	0.03	0.03	0.08	0.08
Feed cost/head, $[b]	43.33	35.16	37.90	31.84	39.18	30.64	39.82	31.85	40.06	32.37
Feed cost/lb. gain, ¢	14.6	14.1	14.4	13.5	12.4	11.6	12.7	11.9	13.5	12.8
Grades										
Initial type[c]	13.2	13.2	12.9	13.0	13.0	13.4	12.9	12.7	13.0	13.1
Final type	13.1	12.5	12.9	12.6	13.0	13.3	12.9	11.9	13.0	12.6
Initial condition[d]	10.1	9.7	9.2	9.3	9.6	9.2	9.0	8.8	9.5	9.3
Final condition	8.8	7.9	9.6	9.5	9.1	9.0	7.7	7.0	8.8	8.4

[a]For the years 1962-63 and 1964-65 a bull was removed from the test due to chronic illness.

[b]Prices used to compute these costs are listed in Table I, page 23.

[c]14, 13 and 12 have been designated as high, average and low choice, respectively.

[d]11, 10 and 9 represent high, average and low good; 8, 7 and 6 represent high, average and low standard, respectively.

TABLE III

ANALYSIS OF VARIANCE OF COMBINED WINTER GAINS

Source of variation	Degrees of freedom	Mean square
Treatment	1	1.9697**
Bulls within treatment	71	0.0707

**P < .01.

during the first part of the winter test than in the other years.

These data indicate that differences in average daily gains during the winter period of approximately 0.30 lb. in favor of treatment BA could be expected when feeding regimes corresponding to treatments BA and CA are followed.

The average daily gain made by the bulls on the BA treatment was comparable to gains obtained by McCampbell, Anderson and Alexander (1929a and 1929b) when a similar ration was fed to weanling steer calves.

Feed consumption and costs. The bulls on the CA treatment consumed an average of 4.19 lb. more silage per day than bulls on the BA treatment. A higher percentage of the nutrients consumed by the bulls on the BA treatment was in the form of concentrates which resulted in an average daily feed cost of 30.0 cents per head as compared to 24.0 cents per head for bulls on the CA treatment. When feed costs were calculated on a cost per pound gained basis, the average was 13.5 cents for the bulls on the BA treatment and 12.8 cents for the bulls on the CA treatment. The difference was not statistically significant as shown in Table IV.

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 type grades throughout this study. At the beginning of the winter period the average type for all years combined was 13.0 and 13.1 for the BA and CA treatments, respectively. At the end of

TABLE IV

ANALYSIS OF VARIANCE OF COST PER POUND OF GAIN
DURING THE WINTER PERIOD

Source of variation	Degrees of freedom	Mean square
Treatment	1	1.0455
Year	3	6.653**
Year X treatment	3	0.0520
Lot/year, treatment	8	0.6257

**$P < .01$.

the winter period the average type for all years combined was 13.0 and 12.6 for the BA and CA treatments, respectively. Table V shows that there was no statistical difference between treatments.

Condition grades. The same numerical system used to evaluate type grades of the bulls was used to score their condition. Condition grades were 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 average condition grade for the bulls on the BA treatment was 9.5 and 9.3 for those on the CA treatment at the beginning of the winter period. At the end of the winter period the average condition for the BA treatment was 8.8 and for the CA treatment 8.4. Table V shows that this difference is statistically significant ($P < .05$). However, one-half of the difference at the end of the winter period was present at the beginning of the winter period. Actually, only a small difference in degree of change in condition grade was observed.

II. PASTURE PERIOD

The performance of the bulls completing the pasture period is shown in Table VI. The average daily gains on pasture ranged from a low of 1.11 lb. in 1961-62 and 1963-64 to a high of 1.39 lb. in 1964-65 for the bulls on the BA treatment and from a low of 1.31 lb. in 1961-62 to a high of 1.93 lb. in 1962-63 for the bulls on the CA treatment. For all years on pasture the CA bulls outgained the BA bulls. The

TABLE V

ANALYSIS OF VARIANCE OF COMBINED TYPE AND CONDITION GRADES AT THE END OF THE WINTER PERIOD

Source of variation	Degrees of freedom	Mean square	
		Type	Condition
Treatment	1	0.1853	3.8470*
Bulls within treatment	71	0.3910	0.5578

*P<.05.

TABLE VI

PERFORMANCE OF THE BULLS DURING THE PASTURE PERIOD

Year	1961-62		1962-63		1963-64		1964-65		1961-64	
Treatment	BA	CA	BA	CA	BA	CA	BA	CA	BA	CA
No. animals	10	10	9	10	10	10	10	9	39	39
No. days on test	101	101	95	95	88	88	81	81	91	91
Av. wt. and gain/head, lb.										
Initial wt.	838	804	851	826	860	794	825	790	844	804
Final wt.	950	936	980	1,009	958	932	938	909	957	947
Total gain	112	132	129	183	98	138	113	119	113	143
Daily gain	1.11	1.31	1.36	1.93	1.11	1.57	1.39	1.46	1.24	1.57
Av. daily feed, lb.										
Hay	0.57	0.53	--	--	2.16	2.15	0.89	0.99	1.21	1.22
Gr. shelled corn	6.91	6.82	6.92	6.92	6.94	6.50	7.20	7.27	6.99	6.88
Corn silage	1.27	1.27	--	--	3.24	4.30	5.05	5.05	3.19	3.54
Cottonseed meal	0.88	0.88	0.77	0.77	1.03	1.04	0.83	0.84	0.88	0.88
Salt and dical.	0.06	0.06	0.03	0.04	0.04	0.04	0.02	0.02	0.04	0.04
Molasses	0.02	0.02	--	--	0.10	0.10	0.05	0.06	0.06	0.06
Feed cost/head, $[a]	28.72	28.10	25.33	25.35	29.94	27.37	36.63	34.12	29.41	28.74
Feed cost/lb. gain, ¢	25.9	20.9	19.9	13.9	19.4	14.2	23.1	22.0	22.1	17.8
Grades										
Initial type[b]	13.1	12.5	12.9	12.6					13.0	12.6
Final type	12.9	12.4	12.8	13.0					12.9	12.7
Initial condition	8.8	7.9	9.6	9.5					9.2	8.7
Final condition	8.7	8.3	9.7	9.5					9.2	8.9

[a]Includes 7 cents per animal day for pasture.

[b]Bulls were not evaluated for type or condition scores at the end of the pasture period for the years of 1963-64 and 1964-65.

differences in gain for different years may be attributed to the following facts.

1. During the pasture period for the years 1962 and 1964 there was dry weather and this resulted in less grass being available for grazing.

2. The bulls were not on the same pastures each year and in the years 1962 and 1964 there was a poorer selection of forage for the bulls to eat.

The combined average daily gains for all years was 1.24 lb. and 1.57 lb. for the BA and CA treatments, respectively. This difference was highly statistically significant as shown in Table VII. These data are in agreement with Lohrding et al. (1959) and Castle, Wallace and Bogart (1961) who found that low winter gains were followed by faster pasture gains. Consequently, they found that total gain for winter and pasture was essentially the same regardless of low or high winter gains.

Feed consumption and cost. The feed consumption for both treatment groups was approximately the same while they were on pasture. In order to obtain complete cost records on the bulls throughout the test, feed 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 feed cost per pound of gain from the end of the winter period until the beginning of the full-feed period was 22.1 cents for the

TABLE VII

ANALYSIS OF VARIANCE OF COMBINED PASTURE AVERAGE DAILY GAIN

Source of variation	Degrees of freedom	Mean square
Treatment	1	19.9153**
Bulls within treatment	71	1.0870

**P < .01.

bulls on the BA treatment and 17.8 cents for the bulls on the CA treatment. These costs include a pasture charge of 7 cents per animal day while the bulls were on pasture.

Type grades. The bulls were not evaluated for type grade at the end of the pasture period for the years 1963-64 and 1964-65. For the combined years of 1961-62 and 1962-63, the average final type score for bulls on pasture was 12.9 and 12.7 for the BA and CA treatments, respectively. There was no statistical difference in type as shown in Table VIII.

Condition grades. Final pasture condition grades were only available for the years 1961-62 and 1962-63. The difference between 9.2 for the bulls on the BA treatment and 8.9 on the CA treatment was not statistically significant.

III. FULL-FEED PERIOD

Following the pasture period, the bulls were placed on a 98-day full-feed test. Table IX shows the performance of the bulls during this period.

Average daily gain. Gains for the BA treatment ranged from a high of 3.29 lb. in 1962-63 to a low of 2.36 lb. in 1964-65 and for the CA treatment from a high of 2.90 lb. in 1962-63 to a low of 2.40 lb. in 1961-62. One explanation for the low gain of the BA bulls in 1964-65 is that one bull in this group failed to eat properly for part of the

TABLE VIII

ANALYSIS OF VARIANCE OF TYPE AND CONDITION GRADES AT THE END OF THE PASTURE PERIOD 1961-62 AND 1962-63

Source of variation	Degrees of freedom	Mean square	
		Type	Condition
Treatment	1	0.3654	1.0538
Bulls within treatment	36	0.5857	0.6436

TABLE IX

PERFORMANCE OF BULLS DURING THE FULL-FEED PERIOD

Year	1961-62		1962-63		1963-64		1964-65		1961-64	
Treatment	BA	CA	BA	CA	BA	CA	BA	CA	BA	CA
No. animals	10	10	9	10	10	10	10	9	39	39
No. days on test	99	99	98	98	99	99	98	98	99	99
Av. wt. and gain/head, lb.										
Initial wt.	950	936	973	1,020	1,004	985	969	945	974	972
Final wt.	1,200	1,174	1,295	1,304	1,296	1,266	1,200	1,199	1,248	1,236
Total gain	250	238	322	284	292	281	231	254	274	264
Daily gain	2.53	2.40	3.29	2.90	2.95	2.84	2.36	2.59	2.77	2.67
Av. daily feed, lb.										
Hay (Alfalfa-grass mix)	7.43	7.20	7.69	7.54	7.81	7.43	7.12	7.30	7.51	7.37
Gr. shelled corn	17.60	16.90	16.07	15.61	18.06	17.28	16.14	16.55	16.97	16.59
Cottonseed meal	2.29	2.20	2.21	2.15	2.42	2.30	2.16	2.22	2.27	2.22
Salt and dical.	0.28	0.28	0.28	0.26	0.30	0.28	0.27	0.28	0.28	0.28
Molasses	1.04	1.00	0.83	0.81	0.91	0.86	0.81	0.83	0.90	0.88
Animal fat	--	--	0.55	0.54	0.61	0.58	0.54	0.55	0.57	0.56
Feed cost/head, $	65.72	63.11	64.40	62.74	71.34	68.05	63.36	64.97	66.21	64.72
Feed cost/lb. gain, ¢	26.5	26.6	20.0	22.0	25.2	24.3	27.4	25.6	24.8	24.6
Grades										
Initial type	12.9	12.4	12.8	13.0					12.9	12.7
Final type	12.6	13.0	13.6	13.8	13.4	13.1	13.4	13.2	13.6	13.4
Initial condition	8.7	8.3	9.7	9.5					9.2	8.9
Final condition	10.4	9.9	11.1	11.1	10.4	10.6	10.5	10.1	10.8	10.5

test due to a chronic bloat condition and averaged gaining 1.69 lb. per day. The average daily gain for the BA group was 2.43 lb. with this bull eliminated. This value is comparable to full-feed average daily gains for other years. There is no definite explanation for the high gains by the BA bulls for 1962-63. However, the CA bulls for that year outgained the CA bulls for all other years indicating a peculiarity of this particular year which influenced the gains of both groups in a similar manner.

The average daily gain for all years combined was 2.77 lb. for the BA treatment and 2.67 lb. for the CA treatment. This difference was not statistically significant (Table X).

Feed consumption and cost. For all years combined, the bulls on the BA and CA treatments consumed virtually the same amount of feed. The cost per pound of gain for the BA treatment was 24.8 cents and 24.6 cents for the CA treatment.

Type grades. The average final type grades for all years combined was 13.6 for the BA treatment and 13.4 for the CA treatment. It is apparent that the two methods of feeding had little, if any, effect on the type scores of the bulls.

Condition grades. The average final condition grade for all years combined was 10.8 for the BA treatment and 10.5 for the CA treatment. There was no statistical difference between treatment differences (Table XI).

TABLE X

ANALYSIS OF VARIANCE OF COMBINED AVERAGE DAILY GAIN DURING THE FULL-FEED PERIOD

Source of variation	Degrees of freedom	Mean square
Treatment	1	0.2036
Bulls within treatment	71	0.1284

TABLE XI

ANALYSIS OF VARIANCE OF COMBINED FINAL TYPE AND CONDITION GRADES

Source of variation	Degrees of freedom	Mean square	
		Type	Condition
Treatment	1	1.1928	0.5285
Bulls within treatment	71	0.5990	0.5990

IV. THE THREE PERIODS COMBINED

Table XII is a summary of the performance of the bulls for the periods combined. The combined average daily gain for the bulls on the BA treatment was 2.11 lb. as compared to 2.05 lb. for the bulls on the CA treatment. There was no statistical difference between treatments (Table XIII).

On a lifetime basis, the bulls on treatment BA had an average daily gain of 1.99 lb. compared to the bulls on the CA treatment which gained 1.96 lb. daily. This difference was not statistically significant (Table XIV).

The total feed cost per bull was $135.67 and $125.82 for the bulls on treatments BA and CA, respectively.

V. CORRELATIONS

Correlations between 21 different measures of pre-weaning, weaning and post-weaning performance traits were obtained on the bulls that completed the BA and CA treatments for the years 1961-62, 1962-63, 1963-64 and 1964-65. The pooled intrayear, intrabreed and intratreatment correlations are given in Table XV.

A brief explanation of some of the traits used to measure performance are as follows:

1. Pre-weaning actual average daily gain was the gain from birth to approximately 120 days of age.

2. Weaning actual average daily gain was the gain from birth to the time the bull calf was removed from his dam (approximately 220-240

TABLE XII

SUMMARY OF BULL'S PERFORMANCE FOR THE THREE PERIODS COMBINED

Year	1961-62		1962-63		1963-64		1964-65		1961-64	
Treatment	BA	CA	BA	CA	BA	CA	BA	CA	BA	CA
No. animals	10	10	9	10	10	10	10	9	39	39
Daily gain, lb.										
Winter	2.09	1.78	2.17	1.82	2.36	1.98	2.24	1.99	2.22	1.90
Pasture	1.11	1.31	1.36	1.93	1.11	1.57	1.39	1.46	1.24	1.57
Full-feed	2.53	2.40	3.29	2.90	2.95	2.84	2.36	2.59	2.77	2.67
3 periods	1.92	1.82	2.27	2.19	2.24	2.17	2.01	2.00	2.11	2.05
Av. initial wt., lb.	546	554	596	606	531	527	510	512	546	550
Av. final wt., lb.	1,200	1,174	1,295	1,304	1,296	1,266	1,200	1,199	1,248	1,236
Av. initial type	13.2	13.2	12.9	13.0	13.0	13.4	12.9	12.7	13.0	13.1
Av. final type	13.6	13.0	13.6	13.8	13.4	13.1	13.4	13.2	13.5	13.2
Av. initial condition	10.1	9.7	9.2	9.3	9.6	9.2	9.0	8.8	9.5	9.3
Av. final condition	10.4	9.9	11.1	11.1	10.4	10.6	10.5	10.1	10.6	10.4
Feed cost/cwt. gain, $	21.07	20.38	18.26	17.18	18.36	17.06	19.83	19.06	19.38	18.42
Total feed cost/bull, $	137.77	126.37	127.63	119.93	140.46	126.06	136.81	130.94	135.67	125.82
Initial cost/bull, $[a]	230.85	234.23	274.99	279.61	210.75	209.17	202.01	202.80	229.65	231.45
Total cost (initial + feed)	368.62	360.60	402.62	399.54	351.21	335.23	338.82	333.74	365.32	357.28

[a]Initial price based on average feeder calf price (of comparable weight and grade steers) in Tenn. Dem. Feeder Calf Sales for each year X 1.5. Av. 1961-64 = $28.04 X 1.5) = $42.06/cwt.

TABLE XIII

ANALYSIS OF VARIANCE OF AVERAGE DAILY GAIN FOR THE THREE PERIODS COMBINED 1962-65

Source of variation	Degrees of freedom	Mean square
Treatment	1	0.8862
Bulls within treatment	71	0.2387

TABLE XIV

ANALYSIS OF VARIANCE OF LIFETIME AVERAGE DAILY GAIN AT THE END OF THE FULL-FEED TEST

Source of variation	Degrees of freedom	Mean square
Treatment	1	0.0862
Bulls within treatment	71	0.1789

TABLE XV

CORRELATIONS AMONG PRE-WEANING, WEANING AND POST-WEANING PERFORMANCE TRAITS

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. Birth weight	-.04	0.19	0.03	-.04	-.24*	-.11	0.18	-.02	0.08	-.07	0.31*	0.07	-.08	0.26*	-.02	0.03	-.06	0.30*	-.06	0.33**
Pre-weaning																				
2. Age		0.05	-.02	0.13	-.04	0.94**	-.17	-.15	0.13	0.09	0.30*	0.12	0.14	-.22	-.10	0.07	0.05	-.02	0.96**	-.07
3. Av. daily gain			0.81**	0.13	0.36**	-.04	0.73**	0.59**	0.10	0.05	0.33**	0.05	0.19	-.11	-.13	-.06	0.01	0.02	0.05	0.42**
4. Adj. av. daily gain				0.10	0.28*	-.08	0.52**	0.89**	0.11	0.05	0.17	-.07	0.07	-.23*	-.16	-.12	0.00	-.16	-.03	0.15
5. Type					0.53**	0.10	-.02	-.01	0.66**	0.46**	0.13	0.47**	0.31*	-.10	-.13	0.31*	0.10	-.06	0.05	-.07
6. Condition						-.03	0.34**	0.24*	0.39**	-.01	-.04	0.21	0.17	0.02	-.04	0.03	0.04	-.07	-.13	0.12
Weaning																				
7. Age							-.20	-.18	0.10	0.04	0.30*	0.16	0.17	-.24*	-.05	0.12	0.11	0.01	0.94**	-.07
8. Av. daily gain								0.61**	0.08	0.05	0.27*	0.12	0.20	-.01	0.02	-.10	0.02	0.13	-.12	0.61**
9. Adj. av. daily gain									0.10	0.05	0.08	-.07	0.03	-.23*	-.08	-.17	-.01	-.16	-.14	0.17
10. Type										0.55**	0.08	0.47**	0.31*	-.02	-.12	0.32**	0.24*	0.01	0.07	0.07
11. Condition											0.00	0.28*	0.22	-.17	0.04	0.26*	0.17	-.03	0.11	0.00
Winter period																				
12. Av. daily gain																				
13. Type											0.38**	0.38**	-.33**	0.11	0.21	0.10	0.50**	0.27*	0.52**	
14. Condition												0.55**	-.26*	0.08	0.46**	0.17	0.21	0.14	0.23*	
													-.16	0.04	0.25*	0.36**	0.21	0.16	0.30*	
Pasture period																				
15. Av. daily gain														-.12	-.16	0.10	0.18	-.26*	0.12	
Full-feed period																				
16. Av. daily gain															0.44**	0.28*	0.75**	-.06	0.55**	
17. Type																0.56**	0.42**	0.08	0.33**	
18. Condition																	0.38**	0.08	0.37**	
19. Av. daily gain for three periods combined																		-.03	0.81**	
Lifetime																				
20. Age																			-.07	
21. Av. daily gain																				

*P<.05.

**P<.01.

days of age).

3. Pre-weaning and weaning adjusted average daily gain was the actual average daily gain multiplied by a correction factor. This correction factor made adjustments for age of dam and sex of the calf.

4. Lifetime average daily gain was computed with this formula.

$$\frac{\text{Final test weight-birth weight}}{\text{days of age}}$$

Birth weight was significantly correlated with winter gain ($r = 0.31$), pasture gain ($r = 0.26$), gain during the three periods ($r = 0.30$) and lifetime average daily gain ($r = 0.33$). It was negatively correlated with condition grade for all periods. Pre-weaning and weaning average daily gain were linearly associated with winter and lifetime average daily gain. Variations in weaning average daily gain accounted for approximately 37 percent of the variation of lifetime average daily gain as compared to pre-weaning average daily gain which accounted for 18 percent. This agrees with correlations of 0.41 for pre-weaning average daily gain and 0.49 for weaning average daily gain with lifetime average daily gain which were reported by Anderson (1962) on correlations calculated for bulls developed on the BA system.

Correlations of all measures of average daily gain with weaning or initial test type grade ranged from -.12 to 0.08. These results agree with those reported by Patterson et al. (1949), Patterson et al. (1955), and Anderson (1962).

The linear association between weaning or initial test type grade and full-feed type grade was 0.32. This was highly significant but

somewhat less than the correlation of 0.724 between initital and final type reported by Patterson et al. (1949).

Winter average daily gain was highly and positively correlated with three period (r = 0.50) and lifetime average daily gain (r = 0.52) and was highly negatively related with pasture average daily gain (r = -.33).

There was a negative correlation between pasture and full-feed average daily gain (r = -.16).

Approximately 56 percent of the variation in three period and 30 percent of the variation in lifetime average daily gain was linearly associated with full-feed average daily gain.

The correlations between daily gains in individual periods and lifetime average daily gain were as follows: daily gain birth to 120 days of age, r = 0.42; actual daily gain birth to weaning, r = 0.61; winter daily gain, r = 0.52; daily gain on pasture, r = 0.12; daily gain on full-feed, r = 0.55; daily gain for three periods, r = 0.81.

These relationships support the following conclusions:

1. The heavier bulls at birth were those which tended to gain more weight and put on less finish up to approximately 20 months of age.

2. Initial type grade alone was of little value in selecting cattle for rapid gain when only calves with a grade of low choice or above were considered. Relation between initial type and lifetime average daily gain was 0.07.

CHAPTER V

SUMMARY

An experiment was designed to compare different amounts of roughage that could be incorporated into a ration for evaluating the productive ability of beef bulls to a breeding age of approximately 20 months. The test consisted of winter, pasture and full-feed periods with the following treatments:

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

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

A total of 78 Angus, Hereford and Polled Hereford bulls completed post-weaning performance tests using the above treatments during the years 1961-62, 1962-63, 1963-64 and 1964-65.

During the winter period the bulls on the BA treatment gained 2.22 lb. per day compared to 1.90 lb. gained by the bulls on the CA treatment. The difference between the two treatment groups was highly significant ($P < .01$). At the end of the winter period bulls that were on the BA treatment scored slightly higher in condition than those on the CA treatment.

During the pasture period the bulls on the CA treatment and the

BA treatment gained an average of 1.57 lb. and 1.24 lb., respectively. The difference between the two groups was highly significant ($P<.01$). The gains made during the winter and pasture periods combined were virtually the same regardless of the level of concentrate feeding during the winter.

The bulls on treatments BA and CA had an average daily gain of 2.77 lb. and 2.67 lb., respectively, during the full-feed period.

Throughout the three periods the bulls on the BA treatment had an average daily gain of 2.11 lb. and those on the CA treatment averaged gaining 2.05 lb. per head per day. The lifetime average daily gain and type and condition grades were slightly higher for the bulls on the BA treatment. However, there was no statistical difference between treatment groups for the entire test period.

Because the bulls on the CA treatment consumed greater amounts of lower-cost corn silage and less concentrates during the winter period than the bulls on the BA treatment the total feed cost per head was $125.82 and $135.67 for the CA and BA treatments, respectively.

The relationships between daily gains in individual periods and lifetime average daily gain were as follows: actual daily gain birth to 120 days of age, $r = 0.42$; actual daily gain birth to weaning, $r = 0.61$; winter daily gain, $r = 0.52$; daily gain on pasture, $r = 0.12$; daily gain on full-feed, $r = 0.55$; daily gain for three periods, $r = 0.81$.

LITERATURE CITED

LITERATURE CITED

Anderson, J. M. 1962. Four methods of developing bulls to approximately 20 months of age. Master's Thesis, The University of Tennessee, Knoxville, Tennessee.

Black, W. H. and B. Knapp, Jr. 1936. A method of measuring performance in beef cattle. Proc. Am. Soc. An. Prod. 29:27.

Black, W. H. and B. Knapp, Jr. 1938. A comparison of several methods of measuring performance in beef cattle. Proc. Am. Soc. An. Prod. 31:103.

Brown, C. J. and Warren Gifford. 1962. Estimates of heritability and genetic correlations among certain traits of performance-tested beef bulls. Ark. Agr. Expt. Sta. Bul. 653.

Castle, E. N., J. D. Wallace and R. Bogart. 1961. Optimum feeding rates for wintering weaner calves. Oregon Agr. Expt. Sta. Tech. Bul. 56.

Clark, R. T., B. Knapp, Jr., A. L. Baker and J. R. Quesenberry. 1943. Performance testing of beef cattle. Mont. Agr. Expt. Sta. Bul. 417.

Duncan, H. R. 1958. Producing beef on grass from yearling and two-year-old steers with and without supplemental feeds. Tenn. Agr. Expt. Sta. Bul. 283.

Dyer, A. J. 1952. Fattening two-year-old steers utilizing maximum amounts of roughage and pasture: a comparison of pastures and wasy to winter cattle. Missouri Agr. Expt. Sta. Progress Report 17:3-5.

Good, E. S. 1926. Wintering steers with and without corn silage preparatory to finishing on grass without grain. Ky. Agr. Expt. Sta. Bul. 267.

Gregory, K. E., R. M. Koch, L. N. Hazel and D. Chambers. 1961. Principals of record of performance in beef cattle. Neb. Agr. Expt. Sta. Circular 106.

Harvey, W. R. 1960. Least squares analysis of data with unequal numbers. U. S. D. A. Agr. Res. Service Bul. ARS-20-8.

Heineman, W. W. and R. W. Van Keuren. 1956. The effect of wintering plane of nutrition on subsequent gains of beef yearling steers on irrigated pastures. J. Animal Sci. 15:1097.

Hobbs, C. S. and J. Anderson. 1962. Four methods of developing bulls to about 20 months of age. Tenn. Farm and Home Sci. Progress Report 40:2.

Holbert, J. 1932. Show ring winnings as a means of evaluating sires. Proc. Am. Soc. An. Prod. 25:52.

Kincaid, C. M., G. W. Litton and R. E. Hunt. 1945. Some factors that influence the production of steers from pasture. J. Animal Sci. 4:164.

Knapka, J. J. 1963. The effect of varying levels of nutrition on growth, development, and fertility of beef bulls. Master's Thesis, The University of Tennessee, Knoxville, Tennessee.

Knapp, B., Jr. and F. N. Baker. 1943. Limited vs. full-feeding in tests on cattle. J. Animal Sci. 2:321.

Lasley, J. F. and B. N. Day. 1960. How to find animals with superior breeding ability. University of Missouri Agr. Expt. Sta. Bul. 757.

Lohrding, C. E., E. F. Smith, B. A. Kock and F. W. Boren. 1959. Winter management for steer calves on a wintering, grazing and fattening program. Kans. Agr. Expt. Sta. Circular 371:26-27.

Marion, P. T., C. E. Fisher and J. N. Jones. 1956. Wintering steer calves at the spur station. Tex. Agr. Expt. Sta. Bul. 835.

McCampbell, C. W., B. M. Anderson and M. A. Alexander. 1929a. Cattle feeding investigations 1927-28, III. Wintering well; grazing without grain to approximately August 1, then full feeding 100 days in a dry lot. Kans. Agr. Expt. Sta. Circular 152:8-13.

McCampbell, C. W., B. M. Anderson and M. A. Alexander. 1929b. Cattle feeding investigations 1928-29. III. Wintering well; grazing without grain to approximately August 1, then full-feeding 100 days in a dry lot. Kans. Agr. Expt. Sta. Circular 152:8-13.

McDaniel, R. C. 1965. Factors affecting beef bull performance to two-years-of-age. Master's Thesis, The University of Tennessee, Knoxville, Tennessee.

Miller, J. I. and F. B. Morrison. 1953a. Use of pasture for fattening steers. I. Comparison of methods for the feeding and management of steer calves. Cornell Univ. Agr. Expt. Sta. Bul. 890:6-15.

Miller, J. I. and F. B. Morrison. 1953b. Use of pasture for fattening steers. III. Effect of age, level of winter feeding and time of grain-feeding on steers fattened on pasture. Cornell Univ. Agr. Expt. Sta. Bul. 890:23-35.

Mott, G. O. and J. R. Miles. 1946. Relationship of certain factors upon gains of steers on pasture. J. Animal Sci. 5:411 (Abstr.).

Patterson, R. E., J. N. Jones, J. J. Bayles and R. V. Turnbough. 1949. Performance testing and progeny testing of beef breeding stock as an aid to selection. J. Animal Sci. 8:608 (Abstr.).

Patterson, R. E., T. C. Cartwright, J. H. Jones and J. J. Bayles. 1955. Performance testing of beef breeding stock. J. Animal Sci. 14:1034.

Ray, L. M. and W. Gifford. 1949. A subjective method of evaluating breeding animals in beef herds--a classification system. J. Animal Sci. 8:608 (Abstr.).

Rollins, W. C., F. D. Carroll, J. W. T. Pollock and M. N. Kudoda. 1962. Beef cattle performance and progeny tests, for gain, efficiency, carcass conformation and earliness of maturity. J. Animal Sci. 21:200.

Sheets, E. W. 1932. Evaluating beef cattle performance for a register of merit. Proc. Am. Soc. An. Prod. 25:41.

Swiger, L. A. 1961. Genetic and environmental influences on gain of beef cattle during various periods of life. J. Animal Sci. 20:183.

Warwick, E. J. 1958. Fifty years of progress in breeding beef cattle. J. Animal Sci. 17:922.

Weber, A. D., F. W. Bell and A. B. Pickett. 1947. Influence of winter rations fed to steer calves upon returns from wintering and grazing. Thirty-fourth annual Feeders Day Report. Kans. Agr. Expt. Sta.

Winters, L. M. and H. McMahon. 1933. Efficiency variation in steers--a proposed record of performance. Minn. Tech. Bul. 94.