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Four methods of developing bulls to approximately 20 months of age

James M. Anderson

To the Graduate Council:

I am submitting herewith a thesis written by James M. Anderson entitled "Four methods of developing bulls to approximately 20 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.

Charles S. Hobbs, Major Professor

We have read this thesis and recommend its acceptance:

R. J. Cooper, H. J. Smith

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

March 9, 1962

To the Graduate Council:

I am submitting herewith a thesis written by James M. Anderson entitled "Four Methods of Developing Bulls to Approximately 20 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:

R. J. Cooper

H. J. Smith

Accepted for the Council:

Hilton A. Smith
Dean of the Graduate School

FOUR METHODS OF DEVELOPING BULLS TO APPROXIMATELY 20 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

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by

James M. Anderson

March 1962

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CHAPTER I

INTRODUCTION

In the southeastern region of the United States there is an abundance of rainfall with warm temperatures for much of the year. These climatic conditions are favorable for the production of large amounts of forages and grains. However, much of the soil in the Southeast cannot compete with that of other areas of the country in the production of grain. The most logical method of producing meat products in this area would appear to be to make maximum use of roughages, provided these roughages could be utilized efficiently.

Making maximum use of large quantities of roughages is "right down the alley" for beef cattle because they have the ability, with the aid of rumen microorganisms, to convert these roughages into a usable product. Most post-weaning performance tests of beef cattle have embraced the idea that the best way to test the gain and feed utilization ability of an animal and his ability to pass these qualities on to his offspring is to feed the maximum amount of grain for 140 days, or some similar feeding period, and use his performance during this time as one of the criteria for selection of breeding stock. The justification for feeding a high-concentrate ration is based on the hypothesis that the performance of individual animals will be spread further apart on a high energy ration than on a low energy ration, and in so doing more information will be obtained on the potential production ability of the animals. There is no doubt that the 140-day

test has been very instrumental in improving the production ability of beef cattle. However, in addition to being able to do a good job of converting concentrates to beef, cattle need to be bred that can ingest large quantities of low-cost roughages and convert these economically into usable products. Beef cattle, when fed primarily grain rations, are in direct competition with other species which have markedly lower feed conversion ratios. Therefore, the ideal performance testing scheme for beef cattle should identify differences in the ability of individual animals to produce high rates of gain on high-roughage, low-cost rations that the competing species cannot utilize as efficiently. Steers need to possess the ability to gain in the feedlot on high-concentrate rations. Yet, if maximum use is made of roughages, the feedlot period needed to produce steers with the amount of finish that most consumers prefer may only be a very small part of the steer's total life span.

Both high-concentrate rations and high-roughage rations have some advantages as the ration to use in measuring post-weaning performance of prospective breeding bulls. Could a combination of these be used, effectively, to performance test beef cattle and to take advantage of the environmental assets of the Southeast? In absence of experimental data of this nature, a Record of Performance Test was designed by members of the Animal Husbandry-Veterinary Science Department at the University of Tennessee with the following objectives in mind:

1. To test the performance of the progeny of various sires.

2. To determine the level of feeding that would do the best job of developing and evaluating bulls to breeding age of approximately

20 months.

This thesis will be concerned with objective two only.

CHAPTER II

REVIEW OF LITERATURE

Much experimental work has been done to determine the optimum method for developing steers being finished for market. There is a considerable amount of experimental data concerning various combinations of wintering, pasturing, and feedlot feeding and management methods for use with steers. However, a diligent search of the literature failed to reveal any data where various feeding combinations had been used for developing beef bulls.

In one of the earlier experiments, Good (1926) fed yearling steers either a full-feed of corn silage in the winter or 5-6 lb. of corn per head per day with no corn silage. Both groups received equal amounts of cottonseed meal and hay. The combined winter and summer gains were 0.06 lb. per day greater for the steers receiving corn silage during the winter. 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 *et al.* (1929a) reported an experiment in which 20 weanling steer calves were fed for 325 days, (December, 1926, to November, 1927). This experiment was divided into three phases--winter, grazing and full feeding. These phases are very comparable in time of year, length of each phase, and method of feeding to the experiment being reported in this thesis. Two treatments were used

with the only difference between treatments being during the winter phase when the steers in lot 1 received 4.66 lb. of corn per head per day and the steers in lot 2 received no grain. Steers in both lots received 1 lb. of cottonseed meal, 2 lb. alfalfa hay and a full feed of corn silage per head per day. During the grazing phase both lots grazed on bluestem pasture, and during the full feeding phase both groups received similar rations. The winter phase lasted 135 days and the average daily gain for the steers in lots 1 and 2 was 2.09 and 1.55 lb., respectively. The grazing phase was for a period of 90 days with the steers in lot 1 gaining 0.85 lb. per day and those in lot 2 gaining 1.26 lb. per day. The full feeding phase lasted for 100 days, and the average daily gain made by steers in lots 1 and 2 was 2.53 and 2.82 lb., respectively. The total gain per steer over the entire 325 days was only 7 lb. greater for the steers receiving corn during the winter than for those receiving no corn during the winter. The authors pointed out that with the exception of the full feeding phase, the gain by the steers in lot 2 was made primarily from low-cost roughages.

An additional report by McCampbell, et al. (1929b) gave the second year's (December, 1927, to November, 1928) results of the experiment described in the preceding paragraph. The primary change in treatment was increasing the daily ration of corn from 4.66 to 5.00 lb. for lot 1 during the winter. The average daily gains during the winter and grazing phases were slightly higher for both lots than those reported in the above paragraph. In contrast to the first experiment, during the full feeding phase the steers in lot 1 and 2

gained 2.86 and 2.76 lb. per day, respectively. The average daily gain for all three phases combined was 1.99 and 1.80 lb. for lots 1 and 2, respectively. The authors concluded that although the gains were greater for the steers in lot 1, a greater use was made of inexpensive roughages by the steers in lot 2.

Dyer (1952) fed 40 head of choice yearling steers on various feedstuffs through three distinct phases--wintering, grazing and full feeding. During the winter phase, part of the steers were wintered on corn silage and red clover hay and the remainder were wintered on bluegrass pasture for 135 days. The grazing phase extended over the period from April 20 to September 30. The full feeding phase began September 30 and continued until the cattle within a treatment would average grading choice. The average daily gain on the silage and red clover hay during the winter was 1.5 lb. The average daily gain for bluegrass pasture was only 0.1 lb. On pasture the cattle that had been on bluegrass during the winter gained fastest. However, their combined gains over the winter and pasture phases was nearly 80 lb. less than that made by the cattle fed silage and hay. The cattle fed silage and hay during the winter took less time in the feedlot to finish out to the choice grade. The author stated that for maximum utilization of roughage and pasture, a plan of management whereby yearling cattle are wintered to gain $1\frac{1}{4}$ to $1\frac{1}{2}$ lb. daily, grazed without grain on a pasture that will put on flesh and then full fed for a short period in dry lot seemed best under Missouri conditions.

Miller and Morrison (1953a) reported 3 years results of wintering

calves with 2 lb. of corn (Lot III) vs. wintering with no corn (Lot IV). A total of 60 steer calves was used in the three trials. 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 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 and 1.04 lb. per day, respectively, for the steers on Lots III and IV during the pasture phase. The length of the finishing period varied from 70-90 days. The average daily gain was 2.24 and 2.17 lb. for Lots III and IV, respectively. For the entire 334 days, Lot III gained 1.41 lb. per day and Lot IV gained 1.33 lb. per day. There was no appreciable difference in cost per head based on the feed prices used.

In another experiment, which consisted of three trials, Miller and Morrison (1953b) wintered 58 steer calves the same way as in the initial experiment. After the winter phase, the steers in Lot III were fed corn on pasture for 130 days. The steers in Lot IV were grazed without grain for 81 days, then fed corn on pasture for 90 days, followed by 40 days in the dry lot. It took 275 days for Lot III to get to market condition and the steers in this lot gained 1.77 lb. per day over the entire period. Lot IV required 356 days to get to market condition and the steers in this lot gained 1.66 lb. per day. The total cost per head was less for Lot III while the cost per pound gain was less for Lot IV. The authors 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: purchasing feeders in the fall, wintering entirely or largely on good roughages, grazing 100 days or more on good pasture, and marketing 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 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 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.

Beef cattle have been evaluated by visual appraisal since the time of Robert Bakewell. However, it has only been during the past 30 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 per cent

and the physical and chemical analysis of the cooked meat.

Holbert (1932) presented a scoring system that he devised which ranked herd sires, within one breed, on the basis of show ring winnings of the individual and his offspring. These winnings would be spread over a large number of shows. In addition, he proposed that the top ranking sires could be given wide publicity. This system would single out lines of breeding which were most consistent in winning premiums.

Winters and McMahon (1933) considered proposals previously made by Holbert (1932) and Sheets (1932) as methods of measuring the performance of beef cattle. They objected to Holbert's proposal because it seemed to intensify selection for type. They disagreed with Sheets' proposal because of the following reasons:

1. It would be complicated and expensive.

2. It would call for the slaughter of too many prospective breeding animals.

3. It would be extremely difficult to make proper adjustments for variations in milk supply during the nursing period.

4. The problem of meat investigation and the job of the producer are distinct and separate--the meat investigator should specify what type animal is desired and the breeder should produce that type of animal.

The authors proposed a method of measuring performance based on average daily gain of the animal from birth to one year of age and a quality score based upon a slaughter grade as determined by a committee of judges.

Black and Knapp (1936) discussed the previous proposals and then stated that they believed that certain conditions must be held constant among animals in a record of performance procedure. These conditions were: weaning weight, slaughter weight, feed, and method of feeding. They further stated that it was important that study be made of the period of development in which there was the most interest, namely from feeder animal to slaughter. They based their method on efficiency of gain from 500 to 900 lb. and a quality score on carcass grade.

Black and Knapp (1938) gave experimental evidence comparing the proposals of Sheets (1932), Winters and McMahan (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 proposed 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. 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) studied results of 8 randomly selected steers from each of 11 purebred Hereford bulls on the basis of weanling weight, feedlot gain, final weight, occurrence of digestive disorders, carcass grade, feed cost per pound of gain, sale value, and gross returns above feed and market costs. The progeny of different bulls ranked differently on the various criteria. Tabulation of the average ranking for each sire enabled judgment to be made of the

respective performance merits on the basis of the factors studied.

The question arose concerning what plane of nutrition would be best to use when measuring performance of beef cattle. Lush (1945) suggested that all animals should be kept under an environment like that for which their offspring are being bred. He suggested that feeding under forced conditions might lead to selection of genes that would not respond well to a less favorable environment.

Knapp and Baker (1943) gave results obtained from limited and unlimited feeding of steers for testing performance in two different years. Variance analyses 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.

After studying results from several experiments, Hammond (1947) made the following statement, "it is concluded, therefore, that since in the later developing characters in animals the environmental conditions, and particularly the nutritional level play such a large part in development, it is only possible to direct evolution by the selection of genes for these characters under circumstances where the environmental conditions are optimal for the development of the character in question."

Falconer and Latyszewski (1952) investigated the effects of environment in relation to selection for size in mice over 8 generations.

They found that improvement of the genotype for growth on a high plane did not result in appreciable improvement for growth on a low plane. In contrast, improvement in the genotype for growth on a low plane resulted in improvement for growth on a high plane. They also observed that the fat content of mice of the full diet strain was about 24 per cent greater than that of the mice of the restricted diet strain after 8 generations of selection, when both were reared on a full diet.

Both pre-weaning and post-weaning performance testing have made rapid strides forward during the past decade. Nearly every state now has some type of program to test the performance of beef cattle. Most of the post-weaning record of performance tests that have been conducted used a standard period of full or ad libitum feeding as suggested by Knapp and Baker (1943) to measure the gainability of beef cattle. Heritability estimates for important characters in beef cattle have been made by Kincaid (1956), Quesenberry (1958), and others during the past decade.

Gregory et al. (1961) have put forth two possible programs for measuring post-weaning performance in bulls. The first possibility was to use the final weight at a standard age of 18 months to measure growth rate. This program would consist of feeding weanling bull calves during their first winter on a relatively low level of concentrate feeding, (4-5 lb. per head per day), plus a full feed of roughage. During the following summer, the bulls are fed at a higher level of concentrates than during the preceding winter, either on grass or in the dry lot. They state that by using this procedure, bulls are

developed at a high enough level of feeding and over a long enough period for genetic differences in growth rate to be expressed. One advantage of this program is that it gives final weight and grade about the normal market age for a high percentage of slaughter cattle. The authors cautioned that the use of post-weaning gain alone as a measure of growth could foster poor milking ability because of compensatory gains. They stated that the pre-weaning and post-weaning gains should be combined and adjusted to about a 550-day weight, then use this weight to measure the growth rate of the bull. An alternate program was offered for measuring growth rate in bulls. This alternate program consists of feeding at a high level and for a shorter period (140-165 days) immediately after weaning. In this program an adjusted final weight at about 365 days could be used as a measure of growth rate. The authors concluded by giving the following principal features of a good record of performance program (includes both pre-weaning and post-weaning):

1. All animals should be given equal opportunity.

2. Systematic, written records must 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 program and management factors must be practical and compatible with those where progeny of herd are expected to perform.

CHAPTER III

EXPERIMENTAL PROCEDURE

A total of 70 Angus and Hereford bulls have completed post-weaning performance tests in this experiment during 1959-60 and 1960-61. The experiment has been divided into winter, pasture, and feedlot periods. In addition to this, 33 Angus and Hereford bulls finished all periods and two of the treatments in 1958-59.

Performance has been measured by gain each period, gain for all three periods, change in type and condition grades, cost of feed required to produce a pound of gain, total cost per head, and lifetime average daily gain to the end of the test.

During all three periods all groups had free access to water, salt, and dicalcium phosphate.

Source of Bulls

The bulls were selected on the basis of weaning weight and grade from seven of the University Experiment Station herds. All of these herds are under similar management programs that exclude unnatural environmental conditions such as creep-feeding or use of nurse cows.

Pre-test Treatment.

All bulls were transferred to the Main Station approximately November 1. For about two weeks they were fed a pre-test ration of 40 per cent concentrates and 60 per cent ground hay. 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 an A or B treatment.

Winter Period

Treatment A consisted of a full-feed of concentrates (ground shelled corn or ground ear corn), approximately 10 lb. of corn silage, 1.5 lb. of cottonseed meal, and 2 lb. of alfalfa hay per animal daily. Treatment B consisted of a full-feed of corn silage, approximately 4 lb. of ground shelled corn, 1.5 lb. of cottonseed meal, and 2 lb. of alfalfa hay per animal daily. When ground ear corn was fed instead of ground shelled corn, the amount fed was approximately equivalent to 4 lb. of shelled corn.

These two treatments were continued for about 140 days (until near April 1). Weights were recorded every 28 days, and feed records were compiled each weigh-day. The bulls were weighed on two consecutive days and graded by members of the Animal Husbandry-Veterinary Science Department to conclude this period of the test.

Pasture Period

At this point in 1958-59, bulls from both the A and B treatments were put on pasture (consisting of orchard grass, Ladino clover, and alfalfa) for a 122-day period.

The 1959-61 tests were altered during the pasture phase in an effort to locate the optimum level of nutrition. The two winter treatment groups (A and B) were each allotted into two treatment groups on pasture. Therefore, combining the winter and pasture periods

resulted in these four treatments:

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

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

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

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

In 1958-59 there were only two treatment groups for the entire test (AB and BB), since all bulls went on pasture with no grain after the winter period. The method of dividing the bulls after the winter period and the method of supplying grain on pasture differed between 1959-60 and 1960-61. The first year the bulls were allotted to either an A or B treatment on pasture according to weight and grade at the end of the winter period. While on pasture these bulls were fed a mixed-hay ration consisting of 60 per cent concentrates and 40 per cent ground hay. The second year the bulls were allotted into four treatment groups (AA, BA, AB, and BB) at the start of the winter period. While on pasture the 1960-61 group was supplied grain by hand-feeding (once each day) 8 lb. per head of a 9:1 corn to cotton-seed meal mixture. They also had access to long orchardgrass hay.

The number of days in the pasture period depended primarily on the availability of good pasture. In 1959-60 the bulls were on pasture for 84 days, whereas, in 1960-61 they were on pasture for 101 days.

At the end of the pasture period the bulls were weighed on two consecutive days, graded by members of the Animal Husbandry-Veterinary Science Department, and this period was terminated.

Feedlot Period

Each year at the end of the pasture period all bulls were full-fed for 98 days. Each treatment group was fed separately so their feed consumption and conversion could be measured. The mixed ration for this period was as follows: (percentages are by weight) 25 per cent ground hay, 63 per cent ground shelled corn, 8 per cent cottonseed meal, 3 per cent molasses, ½ per cent salt, and ½ per cent dicalcium phosphate. 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 per cent hay was increased and the per cent 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. Table I illustrates the average feed consumption for all years and all periods. Table II gives the feed prices that were used to compute cost per pound gain and total costs for all years.

Methods of Analysis

All gains are computed on the basis of bulls that completed all periods of the experiment. Each year, except in 1960-61, 2 to 3 bulls

TABLE I

SUMMARY OF FEED CONSUMPTION BY PERIODS AND YEARS

Year	1958-59		1959-60				1960-61			
Treatment	AB	BB	AA	AB	BA	BB	AA	AB	BA	BB
Av. daily feed intake, lb.										
Winter[a]										
Ground shelled corn	10.16	3.64	13.46[b]	13.46[b]	4.25[b]	4.25[b]	11.86	12.24	4.00	4.00
Ground ear corn	-	-	14.96[b]	14.96[b]	4.91[b]	4.91[b]	-	-	-	-
Corn silage	11.59	26.59	6.32	6.32	27.17	27.17	8.76	8.98	25.90	26.14
Cottonseed meal	1.47	1.46	1.46	1.46	1.46	1.46	1.50	1.50	1.50	1.50
Hay, mixed alfalfa	1.94	1.92	1.95	1.95	1.95	1.95	1.81	1.86	1.84	1.87
Minerals[c]	free choice		0.13	0.13	0.13	0.13	0.07	0.09	0.13	0.10
Pasture										
Ground shelled corn	-	-	6.85	-	8.78	-	7.20	-	7.20	-
Cottonseed meal	-	-	1.08	-	1.39	-	0.80	-	0.80	-
Hay, orchard grass	-	-	5.34	-	6.90	-	1.08	-	0.86	-
Minerals[c]	free choice		0.14	-	0.18	-	0.02	0.02	0.02	0.02
Feedlot										
Ground shelled corn	-	-	15.65	16.21	16.86	15.98	15.75	15.72	17.53	16.11
Ground ear corn	17.61	16.64	-	-	-	-	-	-	-	-
Cottonseed meal	2.27	2.23	1.74	1.81	1.87	1.80	2.07	2.17	2.30	2.22
Hay, mixed alfalfa	8.90	8.27	7.63	8.26	8.21	8.26	7.12	8.18	7.92	8.42
Molasses	0.16	0.16	0.55	0.59	0.59	0.58	0.78	0.81	0.86	0.83
Minerals[c]	0.60	0.58	0.26	0.28	0.29	0.27	0.28	0.30	0.32	0.30

[a]Feed consumption based on 20 bulls on each level (A and B) during the winter period of 1959-60.

[b]Ground ear corn fed first 112 days, ground shelled corn fed the last 28 days.

[c]Includes salt and dicalcium phosphate.

TABLE II

FEED PRICES USED TO COMPUTE FEED COSTS

Ingredient	Price/unit
Ground shelled corn	$ 1.37/bu.
Ground ear corn	1.34/bu.
Cottonseed meal	70.00/ton
Hay (all)	34.00/ton
Corn silage	8.00/ton
Molasses	33.00/ton
Salt	31.00/ton
Dicalcium phosphate	80.00/ton
Pasture (AA, BA)	.05/animal day
Pasture (AB, BB)	.15/animal day

had to be removed from the experiment for various reasons. However, the gain made by these bulls was retained in computing feed costs and conversion because the bulls were fed in groups and not individually.

Treatment differences in rate of gain during all periods and change in type grade were evaluated statistically using analysis of variance. Mean square for lots treated alike was used as the error term for comparison of treatments during the winter period. Because of limited facilities during the pasture and feedlot periods all animals on one treatment were fed or grazed in the same lot. Therefore, the mean square for individual animals was used as the error term instead of the mean square for replications.

Data for all years were pooled and the mean squares for bulls within treatments within years were used as an error term for testing treatment and year differences and for testing treatment x year interaction.

Correlations between eleven different factors used to measure both pre-weaning and post-weaning production ability were computed by treatment group for each year. Also, correlations for years were pooled within a treatment group.

In addition, analysis of variance tests were applied to feed cost per pound of gain during the winter period. The lack of duplicate lots prevented the application of the analysis of variance test to the pasture and feedlot periods.

CHAPTER IV

RESULTS AND DISCUSSION

Average Daily Gain

Table III gives the gains by years and differences between years of bulls on the same treatment are evident. Table IV gives the average daily gain for the two winter period treatments for all years combined. For the two years, 1959-60 and 1960-61, the average daily gain was 2.29 lb. for bulls on the A treatment and 1.97 lb. for bulls on the B treatment. This difference was highly significant ($P < .01$) as shown in Table V. In 1958-59 the gains for bulls on treatments A and B were 2.32 lb. and 2.04 lb., respectively. This difference was significant ($P < .05$) as shown in Table VI.

It should be noted in Table V that the mean square for year variation is greater than the mean square for treatment variation. This indicates a greater difference between years than between treatment within a year. The gains made during 1959-60 were lower than the gains made during 1958-59 and 1960-61. The following reasons are offered as possible explanations for the lower gains made in 1959-60:

1. The average daily gain from birth to weaning was higher than that for 1960-61, therefore the compensatory gains would probably have been less in 1959-60.

2. Ground ear corn was used as a concentrate source for most of this period in contrast to ground shelled corn during the other

TABLE III

SUMMARY OF GAINS AND GRADES BY PERIODS AND YEARS

Year	1958-59		1959-60				1960-61			
Treatment	AB	BB	AA	AB	BA	BB	AA	AB	BA	BB
No. of animals	15	18	11	9	9	9	8	8	8	8
Daily gain, lb.										
Winter	2.32	2.04	2.08	1.99	1.81	1.79	2.49	2.60	2.15	2.13
Pasture	0.74	1.01	1.33	0.50	1.75	0.62	0.87	0.47	1.48	1.01
Feedlot	2.61	2.88	2.19	2.65	2.56	2.65	2.47	2.47	2.88	2.48
3 periods	1.86	1.92	1.91	1.80	2.02	1.75	1.98	1.90	2.16	1.89
Av. initial weight, lb.	528	535	558	557	573	595	562	563	552	575
Av. final weight, lb.	1186	1214	1174	1138	1225	1157	1213	1187	1262	1194
Type grades[a]										
Initial	13.1	12.8	13.3	12.6	12.9	12.9	13.0	12.8	13.1	12.6
End of winter	12.5	11.6	12.8	12.4	11.7	11.9	13.1	12.8	12.2	12.4
End of pasture	12.5	12.3	12.7	12.1	12.2	11.8	13.4	12.9	12.9	12.4
End of feedlot	12.1	12.6	12.8	12.6	13.2	11.8	13.2	12.9	13.3	13.0
Condition grades[b]										
Initial	9.4	9.1	9.4	9.2	8.9	9.1	9.6	9.4	9.4	9.2
End of winter	9.2	8.6	8.3	8.1	7.0	7.4	9.9	9.8	8.8	9.1
End of pasture	5.7	5.7	8.4	7.0	7.9	7.1	10.1	7.9	9.1	7.9
End of feedlot	10.1	10.8	10.1	9.1	10.3	9.7	11.0	9.6	10.8	9.9

[a] 9, 10, 11 - Low, average, and high Good; 12, 13, 14 - Low, average, and high Choice.

[b] 6, 7, 8 - Low, average, and high Standard; 9, 10, 11 - Low, average, and high Good.

TABLE IV

SUMMARY OF GAINS AND GRADES FOR ALL YEARS COMBINED

Years	1959-61				1958-61	
Treatment	AA	AB	BA	BB	AB	BB
No. of animals	19	17	17	17	32	35
Daily gain, lb.						
Winter	2.28	2.30	1.98	1.96	2.30	1.99
Pasture	1.10	0.48	1.62	0.82	0.57	0.88
Feedlot	2.33	2.56	2.72	2.56	2.58	2.67
3 periods	1.94	1.85	2.09	1.82	1.85	1.85
Av. initial weight, lb.	560	560	562	585	549	568
Av. final weight, lb.	1194	1162	1244	1176	1170	1188
Type grades[a]						
Initial	13.2	12.7	13.0	12.8	12.8	12.8
End of winter	13.0	12.6	12.0	12.2	12.6	12.0
End of pasture	13.0	12.5	12.6	12.1	12.5	12.2
End of feedlot	13.0	12.8	13.2	12.4	12.5	12.5
Condition grades[b]						
Initial	9.5	9.3	9.2	9.2	9.3	9.1
End of winter	9.1	9.0	7.9	8.2	9.0	8.4
End of pasture	9.2	7.4	8.5	7.5	6.9	6.9
End of feedlot	10.6	9.4	10.6	9.8	9.6	10.1

[a] 9, 10, 11 - Low, average, and high Good; 12, 13, 14 - Low, average, and high Choice.

[b] 6, 7, 8 - Low, average, and high Standard; 9, 10, 11 - Low, average, and high Good.

TABLE V

VARIANCE ANALYSIS OF COMBINED 1959-60, 1960-61 GAINS

Winter period

Source of variation	DF	Mean square
Year	1	2.4552**
Treatment	1	2.2827**
Y x T	1	.0344
Lots (Y - T)	12	.1026
Bulls (lots- Y - T)	56	.0614

Pasture, feedlot and three periods

		Pasture	Feedlot	3 periods
Source of variation	DF	Mean square	Mean square	Mean square
Year	1	.1998	.0932	.2108*
Treatment	3	4.0071**	.4919*	.2556**
Y x T	3	.5690*	.3603	.0063
Bulls (Y - T)	62	.1922	.1603	.0416

*P $<$ .05

**P $<$ .01

TABLE VI

VARIANCE ANALYSIS OF 1958-59 GAINS

Winter period

Source of variation	DF	Mean square
Treatment	1	.6760*
Lots (treatment)	5	.1015
Bulls (lots)	28	.0928

Pasture, feedlot, three periods

		Pasture	Feedlot	3 periods
Source of variation	DF	Mean square	Mean square	Mean square
Treatment	1	.6058	.6187	.0319
Bulls (treatment)	31	.1478	.1690	.0378

*$P < .05$

years (Table I). This could have limited the total energy intake, particularly of the bulls on A treatment.

3. The bulls on the 1959-60 test experienced considerable sickness during the first 28 days of the winter period.

These data indicate that differences in average daily gains during the winter period of 0.30 lb. to 0.40 lb. in favor of treatment A could be expected when feeding regimes corresponding to treatment A and treatment B are followed.

The gains made during the winter by the bulls on the B treatment are very comparable to the gains obtained by McCampbell et al. (1929a and 1929b) when a similar ration was fed to weanling steer calves.

The average daily gain during the pasture period for the two years (1959-61) is listed by treatment groups in Table IV. The gain by bulls on treatments AA, AB, BA, and BB was 1.10 lb., 0.48 lb., 1.62 lb., and 0.82 lb., respectively, for 1959-61 combined. Treatment differences were found to be highly significant ($P < .01$) and there was a significant ($P < .05$) year x treatment interaction (Table V). Results of mean separation using Duncan's Multiple Range Test are shown in Table VII. For the two years combined bulls on treatment BA outgained all other treatments ($P < .01$), bulls on treatment AA gained more than those on treatment AB ($P < .01$), and bulls on treatment BB outgained those on treatment AB ($P < .05$).

The significant year x treatment interaction probably resulted because treatment AA ranked second in 1959-60 and third in 1960-61. Treatment BB ranked third in 1959-60 and second in 1960-61. Possible

TABLE VII

MEAN SEPARATION FOR GAINS[a]

Year	1959-60	1960-61	1959-60 1960-61
Period[b]			
Pasture	BA>AB, BB P<.01 BA>AA P<.05 AA>AB, BB P<.05	BA>AB P<.01 BA>AA P<.05 BB>AB P<.05	BA>AA, BB, AB P<.01 AA>AB P<.01 BB>AB P<.05
Feedlot	BA>AA P=.05 AB, BB>AA P<.05	F test not significant	BA>AA P<.01
3 periods	BA>BB P<.01 BA>AB P<.05	BA>AB, BB P<.05[c]	BA>AB, BB P<.01 BA>AA P<.05

[a]Means separated using Duncan's Multiple Range Test.

[b]Winter period not included because there were only two treatment means during this period.

[c]F test was significant at the 10 per cent level.

explanations for this change in rank are:

1. The differences between the two years in the method of supplying grain on pasture.

2. The difference in the length of the pasture period (84 days in 1959-60 and 101 days in 1960-61).

3. The difference in the gains made during the winter period of 1959-60 and the gains made during the same period in 1960-61.

In 1958-59 bulls on treatments BB and AB gained 1.01 lb. and 0.74 lb., respectively during the pasture period. This difference approaches significance at the 95 per cent level of probability.

The results for the pasture period are comparable to those reported by McCampbell (1929a and 1929b) for treatment BB. These data are in agreement with Lohrding et al. (1959) who found that poor winter gains were compensated for by faster pasture gains, and as a consequence total gains for winter and pasture combined were essentially the same regardless of high or low winter gains. These data do not agree with Miller and Morrison (1953a) and Embry et al. (1958) who reported that increased winter gains resulted in increased total gains when winter and pasture gains were combined.

Based on these results, a high level of nutrition (treatment A) during the winter should be followed with some concentrate feeding during the pasture season. This method of feeding is necessary to avoid the extremely low gains resulting from pasture alone after concentrate feeding in the winter. If the level of nutrition is comparable to treatment B during the winter, then it appears that greater use of

pasture could be obtained by using pasture alone during the grazing season, provided the grazing season extends for at least 100 days. However, if increased gain is desired after bulls are wintered on a level comparable to treatment B, then grain should be available during the grazing season.

Gains during the feedlot period were relatively uniform between years. The average daily gains made by bulls on treatments AA, AB, BA, and BB for two years (1959-61) combined were 2.33 lb., 2.56 lb., 2.72 lb., and 2.56 lb., respectively. For 1959-61 the only significant difference was between the means of treatment BA and treatment AA ($P < .01$). This difference is shown in Table VII. Gain made on treatment AA was considerably less than that of the other treatments in 1959-60. This probably reflects the high gain made on treatment AA during the pasture period in 1959-60 as compared to the gain made in 1960-61. As a result of these good gains during the pasture period, there was less compensatory gain made in the feedlot period. These results indicate that feeding on a high level during both the winter and pasture periods will reduce the gain obtained during the feedlot period.

As in previous periods, the gains during the feedlot period by treatment BB are very comparable to those obtained by McCampbell et al. (1929a and 1929b) feeding yearling steers.

The gains made for the three periods combined are summarized in Table IV. The rank of treatments was the same for both 1959-60 and 1960-61. Daily gains for bulls on treatments AA, AB, BA, and BB

for 1959-61 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 3-year average daily gain for bulls on treatments AB and BB was 1.85 lb. each.

From these data it can be 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. Actually, the information in Table VI shows that bulls on treatment BA gained significantly more ($P < .05$) than bulls on treatment AA over the entire test.

Lifetime average daily gain to the end of the test was 1.88 lb., 1.86 lb., 1.98 lb., and 1.84 lb., for bulls on treatments AA, AB, BA and BB, respectively.

There are no definite explanations for why the use of treatment BA resulted in more gain, however, the following statements are offered as possible reasons:

1. It is possible that in consuming a bulky ration during the winter period, the bulls on treatment BA increased the size of their rumen, thus increasing the rumen capacity and absorption area available during the remainder of the experiment.

2. Another possibility is that the total energy intake was never drastically changed for bulls on treatment BA as it was with the other treatments. This probably prevented any serious metabolic adjustments from being made during the experiment. An example of this type of adjustment is the change in requirement of microflora necessary

to act upon the feed consumed when the ration being fed to cattle is changed from concentrate to roughage or from roughage to concentrate.

3. Compensatory gains made by bulls on treatment BA during the pasture and feedlot periods probably accounted for the narrowing of the difference between treatments AA and BA, however compensating gain could hardly be said to be the whole reason for bulls on treatment BA outgaining those on treatment AA.

Type Grade

There was no consistent trend in change of type grade from the beginning of the winter period to the end of the feedlot period. As shown in Table IV, type grade for bulls on treatments AB and BA increased slightly and for bulls on treatments AA and BB decreased slightly. Considering the 1959-60 results independently, the bulls on treatment BA increased in type grade, the bulls on treatment AB remained the same, the bulls on treatment AA decreased slightly, and those on treatment BB decreased considerably (Table III). There was a significant difference ($P < .05$) between treatments BA and AA and between treatments AA and BB. The difference between treatments BA and BB was highly significant ($P < .01$) as was the difference between treatments AB and BB. This same trend was not true in 1960-61 and the type grade changes were about identical for all treatments. There was a significant difference ($P < .05$) between years.

The average change in type grade for bulls on treatments AB and BB was the same for the three years combined (1958-61).

Condition Grade

There was a rather constant trend established for change in condition grade from the beginning to the end of the experiment. Bulls on treatment AA and BA increased about one-third of a grade for the two years (1959-61). Bulls on treatment BB increased about one-sixth of a grade and those on treatment AB remained about the same.

For treatments AA and BA the lowest average condition grade for the two years (1959-61) was recorded at the end of the winter period. For treatments AB and BB the lowest average condition grade for the three years (1958-61) was at the end of the pasture period. All of these data are recorded in Tables III and IV.

Feed Cost

The information contained in Tables VIII and IX show that the difference in feed cost per pound of gain between treatments A (AA, AB) and B (BA, BB) during the winter was 2.8 cents in favor of treatment B for the two years (1959-61). In 1958-59 the feed cost was 3.1 cents more per pound of gain for treatment A than for treatment B. The difference for both the two years (1959-61) and 1958-59 was highly significant ($P < .01$). The mean squares are shown in Table X. As was the case with average daily gain, the mean square for year variation was about the same as the mean square for treatment variation. This resulted because the difference between cost per pound of gain for years was about the same as the difference between treatments within a year.

The total feed cost per head for bulls on treatment B was about

TABLE VIII

SUMMARY OF FEED COST BY PERIODS AND YEARS

Year	1958-59		1959-60				1960-61			
Treatment	AB	BB	AA	AB	BA	BB	AA	AB	BA	BB
Feed cost per lb. gn., cents[a]										
Winter	16.4	13.6	19.0	19.0	16.2	16.2	16.8	16.6	13.8	14.0
Pasture	20.2	14.8	26.4	29.8	25.1	24.2	31.4	32.0	18.2	15.0
Feedlot	22.7	19.3	27.0	23.3	24.8	23.1	24.8	25.8	23.6	26.3
3 periods	19.3	16.2	23.1	21.7	21.5	20.1	21.8	21.3	18.6	18.9
Total feed cost per head, dollars[a]										
Winter	51.04	37.29	56.14	56.14	40.59	40.59	53.97	55.53	38.20	38.37
Pasture	18.30	18.30	29.45	12.60	36.78	12.60	27.60	15.22	27.24	15.22
Feedlot	57.92	54.45	57.85	60.61	62.30	59.96	60.01	62.12	66.70	63.75
3 periods	127.26	110.04	143.44	129.35	139.67	113.15	141.58	132.87	132.14	117.34

[a]Prices used to compute these costs are listed in Table II.

TABLE IX

SUMMARY OF FEED COST FOR ALL YEARS COMBINED

Year	1959-61 (two years)				1958-61 (three years)	
Treatment	AA	AB	BA	BB	AB	BB
Feed cost per lb. gn., cents[a]						
Winter	17.9	17.8	15.0	15.1	17.3	14.6
Pasture	28.9	30.9	21.6	19.6	27.3	18.0
Feedlot	25.9	24.6	24.2	24.7	23.9	22.9
3 periods	22.4	21.5	20.0	19.5	20.8	18.4
Total feed cost per head, dollars[a]						
Winter	55.06	55.84	39.40	39.48	54.24	38.75
Pasture	28.52	13.91	32.01	13.91	15.37	15.37
Feedlot	58.93	61.36	64.50	61.86	60.22	59.39
3 periods	142.51	131.11	135.90	115.24	129.83	113.51

[a]Prices used to compute these costs are listed in Table II.

TABLE X

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

1959-60, 1960-61 combined

Source of variation	DF	Mean square
Year	1	25.4520**
Treatment	1	33.3506**
Y x T	1	.0122
Lots (Y - T)	12	1.9459

1958-59

Source of variation	DF	Mean square
Treatment	1	12.0688**
Lots (treatment)	5	.1689

**P < .01

16 dollars less than that for bulls on treatment A during the winter for each year the test was conducted (1958-61).

The feed cost per pound of gain during the pasture period was about 9.3 cents higher for the bulls that had been on treatment A during the previous winter period (AA, AB) than it was for bulls that had been on treatment B (BA, BB). The total feed cost per head was about 16 dollars greater for the two grain-fed treatments, AA and BA, than for treatment AB and BB.

The only differences of importance during the feedlot period were that the feed cost per pound of gain for treatment AA was about 1.2 cents greater than treatments AB and BB and treatment BA was about 0.4 cents less than treatments AB and BB. The total feed costs during the feedlot period were 64.50, 61.86, 61.36, and 58.93 dollars for treatments BA, BB, AB, and AA, respectively (Table IX).

The feed cost for three periods (winter, pasture, and feedlot) is summarized in Tables VIII and IX. The costs per pound of gain were 22.4, 21.5, 20.0, and 19.5 cents for treatments AA, AB, BA, and BB, respectively. The total feed costs per head were 142.51, 131.11, 135.90, and 115.24 dollars for treatments AA, AB, BA, and BB, respectively (Table IX).

These results indicate that of the treatments tested, the lowest feed cost per pound of gain and per head may be had by following a system similar to treatment BB. Also, this treatment makes the greatest use of roughages (silage and pasture) of all treatments tested. It must be remembered, however, that use of treatment BB results in

the lowest gains of all methods tested (Table IV). 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 (Table VII).

Correlations

Correlations within a treatment were obtained between eleven different measures of pre-weaning, weaning, and post-weaning performance. Pre-weaning actual average daily gain is the gain from birth to approximately 120 days of age. Weaning actual average daily gain is the gain from birth to the time the bull calf is removed from his dam (approximately 220-240 days of age). Weaning adjusted average daily gain is the actual average daily gain multiplied by a correction factor. This correction factor makes adjustment for age of dam and sex of the calf. The adjusted 220-day weight is the birth weight added to the weaning adjusted average daily gain multiplied by 220. Lifetime average daily gain is computed with this formula:

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

The pooled intrayear correlations are given in Table XI. The correlations for each year separately are given in Tables XII, XIII, XIV, and XV for treatments AA, BA, AB, and BB, respectively. Only the pooled post-weaning data will be discussed in detail in this thesis.

There are some notable relationships between pre-weaning, weaning, and post-weaning performance which should be mentioned. The positive relationships between pre-weaning gain and winter period

TABLE XI

POOLED INTRAYEAR CORRELATIONS BETWEEN VARIOUS PRE-WEANING AND POST-WEANING MEASURES OF PERFORMANCE

N_{AA}(59-61)=19 N_{AA}(58-61)=32 N_{AB}(59-61)=17 N_{BA}(58-61)=34 N_{BB}(58-61)=34	Treat-ment	Act. ADG Bir.-wn.	Adj. ADG Bir.-wn.	ADG Win.	ADG Pas.	ADG Feedlot	ADG 3 Per.	Lifetime ADG	Initial type	Final type
Pre.-wn.	AA	.746**	.636**	.405	.139	.339	.523*	.723**	.336	-.156
Act. ADG	AB	.582**	.428*	.217	-.015	.253	.317	.524**	.013	.081
	BA	.772**	.537*	.572*	-.068	.061	.261	.490	-.215	.141
	BB	.660**	.512**	.488**	.262	.186	.519**	.628**	-.059	.135
Act. ADG	AA		.815**	.419	-.200	.353	.254	.607**	.310	-.137
Bir.-wn.	AB		.867**	.460*	-.326	.391*	.369	.683**	-.064	.229
	BA		.772**	.518*	-.339	-.019	.082	.411	-.143	.025
	BB		.911**	.235	.173	.295	.424*	.660**	-.083	-.024
Adj. ADG	AA			.450	-.047	.337	.392	.701**	.136	.001
Bir.-wn.	AB			.368	-.274	.304	.281	.540**	-.225	.157
	BA			.410	.029	.274	.368	.599*	-.191	.229
	BB			.115	.027	.293	.236	.465**	-.045	-.123
ADG	AA				-.092	.414	.719**	.825**	-.092	.111
Winter	AB				-.683**	.472*	.543**	.611**	.020	.349
	BA				.073	.039	.499	.701**	.071	.443
	BB				.042	-.028	.600**	.585**	-.474**	.187
ADG	AA					-.389	.510*	.132	-.511*	-.267
Pasture	AB					-.289	.002	-.208	-.268	-.149
	BA					.429	.690**	.486	-.519*	.229
	BB					-.280	.641**	.492**	-.437**	.086
ADG	AA						.409	.528*	-.016	.054
Feedlot	AB						.861**	.830**	-.329	.393*
	BA						.811**	.645**	-.126	.211
	BB						.295	.334	.228	-.035
ADG	AA							.849**	-.449	-.099
3 Per.	AB							.871**	-.400*	.405*
	BA							.905**	-.319	.416
	BB							.899**	-.495**	.163
Lifetime	AA								-.115	.031
ADG	AB								-.377*	.406*
	BA								-.269	.454
	BB								-.398*	.244
Initial	AA									.599*
Type	AB									.048
	BA									.233
	BB									.247

* P<.05

** P<.01

gain, three period gain, and lifetime average daily gain are just as great as the relationship between weaning actual average daily gain and these post-weaning factors. Approximately 20 to 50 per cent of the variation in lifetime average daily gain for all treatments is linearly associated with pre-weaning actual average daily gain or the weaning actual average daily gain.

There are several important relationships between post-weaning measures of performance which will be discussed. Initial type was negatively correlated with all measures of gain on test and lifetime average daily gain with three exceptions. The three correlations that were not negative were only slightly positive. These results agree with those reported by Patterson et al. (1949) and Patterson et al. (1955) who reported a small negative correlation between type score and feedlot gain. Knapp and Clark (1951) reported a gross correlation of 0.0001 between weaning score and gains in the feedlot.

Winter gain for bulls on treatments AA and AB was positively correlated (0.414 and 0.472) with feedlot gain. The correlations between winter gain and feedlot gain for treatments BA and BB were 0.039 and -.028, respectively. A possible explanation for this is that the higher gaining bulls during the winter period on treatments AA and AB were more adversely affected by the pasture period than the lower gaining bulls in these treatment, and they tended to make more compensatory gains during the feedlot period.

There was a negative correlation between pasture gain and feedlot gain for bulls on all treatments except BA. For bulls on the

BA treatment, the correlation was 0.429.

Approximately 25 to 35 per cent of the variation in three period gain was linearly associated with pasture gain for bulls on treatments AA, BA, and BB.

Pasture gain by bulls on treatments BA and BB was positively correlated (0.486 and 0.492) with lifetime average daily gain.

Forty to sixty per cent of the variation in three period and lifetime gain for bulls on treatments AB and BA was linearly related with feedlot gain. Feedlot gain was positively (0.528) correlated with lifetime average daily gain for treatment AA.

Initial type score was positively correlated with final type score. However, these values were small for the most part and were significant only for treatment AA. The reason for this low relationship possibly lies in the fact that there is a narrow range from lowest to highest in type score.

Generally, there was a small positive correlation between test gains and final type. Patterson et al. (1955) reported a relationship of 0.17 between feedlot average daily gain and final type.

These correlations support the following conclusions:

1. Pre-weaning actual average daily gain has just as great a relationship with winter gain, three period gain, and lifetime average daily gain as does weaning actual average daily gain.

2. Winter gain on treatments AA and AB is negatively related with pasture gain and is more highly correlated, positively, with feedlot gain than the winter gain made by treatments BA and BB.

3. Forty to sixty per cent of the variation in lifetime gain by treatments BA and AB is linearly associated with feedlot gain.

4. Initial type alone is of little value in selecting cattle for rapid gain when only calves with a grade of 12 or above are considered.

5. Initial type score is not highly related to final type grade, except in treatment AA.

6. There is a small positive relationship between gain on test and final type in most instances.

7. The correlations between daily gains in individual periods and lifetime average daily gain were as follows: actual daily gain birth to 120 days of age, $r = 0.49$ to 0.72; actual daily gain birth to weaning, $r = 0.41$ to 0.66; adjusted daily gain birth to weaning, $r = 0.46$ to 0.70; winter daily gain, $r = .58$ to $.82$; daily gain on pasture, $r = -.21$ to 0.49; daily gain in feedlot, $r = 0.33$ to 0.83.

CHAPTER V

SUMMARY

Four levels of feeding were used to determine which level would do the best job of developing and evaluating bulls to a breeding age of approximately 20 months. The following treatments covered three periods (winter, pasture, and feedlot):

AA - Full-feed of grain and limited quantities of silage during the winter, limited amounts of grain on pasture, and full-feed of concentrates in the feedlot.

BA - Full-feed of silage and limited amounts of grain during the winter, limited amounts of grain on pasture, and full-feed of concentrates in the feedlot.

AB - Full-feed of grain and limited quantities of silage during the winter, no grain on pasture, and full-feed of concentrates in the feedlot.

BB - Full-feed of silage and limited amounts of grain during the winter, no grain on pasture, and full-feed of concentrates in the feedlot.

A total of 70 Angus and Hereford bulls completed post-weaning performance tests using the above treatments during 1959-60 and 1960-61. In addition, 33 Angus and Hereford bulls completed treatments AB and BB in 1958-59.

The results have been discussed and the following observations

are made:

1. Although the gain was higher for bulls on treatment A (AA, AB) than for bulls on treatments B (BA, BB) during the winter period, this advantage was not apparent in the overall gain for the three periods.

2. The greatest use of roughages (silage and pasture) was made by bulls on treatment BB and this resulted in the most economical gains of all methods tested.

3. Bulls on treatment BA outgained those on treatment AA ($P < .05$). The gain by bulls on treatment BA was made with greater use of roughages (silage and pasture) than the gain made by bulls on treatment AA.

4. Treatments had no marked effect on type grade.

5. Condition grade was considerably higher at the end of the test for bulls on treatments AA and BA.

6. Treatments BA and BB more nearly parallel the methods likely to be used in the Southeast to grow out and fatten the bulls' progeny.

7. There was a negative relationship between winter gain and pasture gain for bulls on treatments AA and AB in contrast to a positive correlation for bulls on treatments BA and BB. There was a high positive correlation between winter gain and feedlot gain for bulls on treatments AA and AB, whereas there was very little relationship between winter gain and feedlot gain for bulls on treatments BA and BB.

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LITERATURE CITED

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APPENDIX

TABLE XII

CORRELATIONS BETWEEN VARIOUS PRE-WEANING AND POST-WEANING MEASURES OF PERFORMANCE OF BULLS DEVELOPED ON TREATMENT AA (1959-60, 1960-61)

N_{60} = 11 N_{61} = 8	Yr.	Act. ADG Bir.-wn.	Adj. ADG Bir.-wn.	Adj. 220 day wt.	ADG Win.	ADG Pas.	ADG Feedlot	ADG 3 per.	Lifetime ADG	Initial type	Final type
Pre.-wn.	60	.925**	.786**	.867**	.618*	.074	.138	.519	.756**	.259	-.044
Act. ADG	61	.286	.125	.361	.058	.294	.735*	.571	.630	.505	-.448
Act. ADG	60		.843**	.884**	.498	.068	.169	.449	.700*	.290	-.234
Bir.-wn.	61		.760*	.852**	.315	-.735*	.653	-.049	.386	.356	.074
Adj. ADG	60			.957**	.635*	.109	.270	.612*	.821**	.144	-.012
Bir.-wn.	61			.943**	.137	-.461	.519	-.018	.330	.144	.041
Adj. 220	60				.733*	.233	.164	.723*	.897**	.131	-.015
day wt.	61				.093	-.460	.637	.011	.382	.315	.081
ADG	60					.070	.278	.820**	.929**	.139	.390
Winter	61					-.318	.561	.609	.703	-.317	-.311
ADG	60						-.588	.541	.140	-.331	-.171
Pasture	61						-.117	.473	.118	-.758*	-.458
ADG	60							.157	.319	.409	.343
Feedlot	61							.690	.912**	-.436	-.388
ADG	60								.845**	.012	.264
3 per.	61								.901**	-.918**	-.676
Lifetime	60									.259	.302
ADG	61									-.698	-.616
Initial	60										.546
Type	61										.710*

* $P < .05$

** $P < .01$

TABLE XIII

CORRELATIONS BETWEEN VARIOUS PRE-WEANING AND POST-WEANING MEASURES OF PERFORMANCE OF BULLS DEVELOPED ON TREATMENT BA (1959-60, 1960-61)

$N_{60} = 9$ $N_{61} = 8$	Yr.	Act. ADG Bir.-wn.	Adj. ADG Bir.-wn.	Adj. 220 day wt.	ADG Win.	ADG Pas.	ADG Feedlot	ADG 3 per.	Lifetime ADG	Initial type	Final type
Pre.-wn.	60	.627	.272	.424	.299	-.178	-.123	.066	.304	-.684*	-.218
Act. ADG	61	.903**	.792*	.757*	.958**	-.020	.200	.388	.641	.171	.444
Act. ADG	60		.841**	.883**	.300	-.424	-.154	-.029	.339	-.616	-.306
Bir.-wn.	61		.705	.667	.833*	-.320	.086	.155	.471	.258	.312
Adj. ADG	60			.964**	.205	-.483	.031	.022	.359	-.231	-.256
Bir.-wn.	61			.989**	.715*	.296	.478	.617	.814*	-.156	.676
Adj. 220	60				.304	-.372	.123	.185	.525	-.309	-.146
day wt.	61				.685	.368	.573	.695	.865**	-.224	.636
ADG	60					.056	-.058	.654	.792*	-.113	.573
Winter	61					.101	.151	.423	.638	-.024	.306
ADG	60						.003	.321	.265	.070	.529
Pasture	61						.616	.821*	.603	-.809*	.104
ADG	60							.664	.384	.284	.511
Feedlot	61							.894**	.826*	-.416	-.005
ADG	60								.881**	.146	.896**
3 per.	61								.930**	-.598	.137
Lifetime	60									-.074	.687*
ADG	61									-.417	.276
Initial	60										.292
Type	61										.189

* $P < .05$

** $P < .01$

TABLE XIV

CORRELATIONS BETWEEN VARIOUS PRE-WEANING AND POST-WEANING MEASURES OF PERFORMANCE OF BULLS DEVELOPED ON TREATMENT AB (1958-59, 1959-60, 1960-61)

N_{59} = 15 N_{60} = 9 N_{61} = 8	Year	Act. ADG Bir.-wn.	Adj. ADG Bir.-wn.	Adj. 220 day wt.	ADG Win.	ADG Pas.	ADG Feedlot	ADG 3 per.	Lifetime ADG	Initial type	Final type
Pre.-wn.	59	.879**	.788**	.807**	.481	-.337	.077	.167	.529*	.103	.100
Act. ADG	60	.205	.004	.081	.319	-.550	.615	.506	.542	.123	.345
	61	.081	-.074	.105	-.448	.595	.364	.553	.507	-.459	-.111
Act. ADG	59		.849**	.873**	.631*	-.462	.309	.352	.653**	.084	.297
Bir.-wn.	60		.896**	.952**	.237	-.424	.455	.374	.737*	-.364	-.349
	61		.909**	.894**	.199	-.153	.568	.423	.722*	-.391	.438
Adj. ADG	59			.984**	.471	-.371	.238	.253	.491	-.109	.144
Bir.-wn.	60			.960**	.136	-.373	.414	.305	.627	-.512	-.382
	61			.970**	.310	-.155	.341	.328	.601	-.392	.567
Adj. 220	59				.470	-.315	.264	.303	.519*	-.068	.192
day wt.	60				.175	-.291	.389	.333	.687*	-.315	-.306
	61				.356	-.135	.352	.393	.660	-.392	.596
ADG	59					-.650**	.662**	.730**	.826**	-.179	.283
Winter	60					-.629	.519	.761*	.622	.178	.334
	61					-.794*	.032	-.028	.028	.657	.601
ADG	59						-.424	-.132	-.420	-.204	-.108
Pasture	60						-.619	-.524	-.626	.314	-.016
	61						-.026	.403	.277	-.789*	-.303
ADG	59							.872**	.830**	-.403	.653**
Feedlot	60							.913**	.869**	-.346	.027
	61							.776*	.802*	-.055	-.163
ADG	59								.861**	-.507	.572*
3 per.	60								.859**	-.090	.193
	61								.927**	-.343	.012
Lifetime	59									-.417	.549*
ADG	60									-.177	-.048
	61									-.456	.180
Initial	59										-.032
Type	60										.733*
	61										.038

* $P < .05$

** $P < .01$

TABLE XV

CORRELATIONS BETWEEN VARIOUS PRE-WEANING AND POST-WEANING MEASURES OF PERFORMANCE OF BULLS DEVELOPED ON TREATMENT BB (1958-59, 1959-60, 1960-61)

N_{59} = 17, N_{60} = 9, N_{61} = 8	Year	Act. ADG Bir.-wn.	Adj. ADG Bir.-wn.	Adj. 220 day wt.	ADG Win.	ADG Pas.	ADG Feedlot	ADG 3 per.	Lifetime ADG	Initial type	Final type
Pre.-wn.	59	.609**	.469	.514*	.469	.224	.217	.619**	.639**	-.141	.089
Act. ADG	60	.859**	.747*	.773*	.626	.409	.094	.666*	.905**	.089	.382
	61	.544	.474	.496	-.582	.254	.315	.014	.225	.000	-.197
Act. ADG	59		.932**	.956**	.149	.048	.314	.325	.556*	.014	-.186
Bir.-wn.	60		.903**	.950**	.666*	.604	.136	.845**	.933**	-.224	.003
	61		.849**	.895**	.108	.012	.496	.290	.695	-.385	.506
Adj. ADG	59			.990**	.010	-.065	.376	.168	.386	.100	-.262
Bir.-wn.	60			.981**	.805**	.622	-.017	.842**	.858**	-.341	-.161
	61			.978**	-.050	-.286	.359	-.058	.388	-.402	.372
Adj. 220	59				.058	-.005	.368	.247	.449	.023	-.307
day wt.	60				.753*	.683*	.043	.889**	.905**	-.279	-.080
	61				-.097	-.144	.512	.082	.504	-.463	.378
ADG	59					-.113	.204	.711**	.681**	-.540*	.046
Winter	60					.736*	-.542	.706*	.724*	-.554	.051
	61					-.157	-.219	.320	.337	-.196	.657
ADG	59						-.568*	.444	.318	-.483*	.095
Pasture	60						-.337	.856**	.701*	-.423	.095
	61						.470	.803*	.568	-.481	.056
ADG	59							.232	.303	.188	-.105
Feedlot	60							.084	.098	.526	-.133
	61							.649	.716*	-.492	.253
ADG	59								.914**	-.668**	.057
3 per.	60								.916**	-.272	.004
	61								.882**	-.644	.492
Lifetime	59									-.592*	-.002
ADG	60									-.121	.233
	61									-.712*	.686
Initial	59										.282
Type	60										.504
	61										-.651

* $P < .05$

** $P < .01$