A COMPARISON IN FEEDLOT PERFORMANCE OF STEERS ALLOWED A GROWING PERIOD WITH STEERS PLACED ON A FINISHING RATION AT WEANING

By

LELAN RAY LANCASTER

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1971

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
July, 1972

A COMPARISON IN FEEDLOT PERFORMANCE OF STEERS
ALLOWED A GROWING PERIOD WITH STEERS PLACED
ON A FINISHING RATION AT WEANING

Thesis Approved:

Richard R Frahm
Thesis Adviser

Irvin T Omtvedt

Donald G Wagner

N Durham
Dean of the Graduate College

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Dr. Richard R. Frahm, Associate Professor of Animal Science, for his suggestions, encouragement and counsel throughout the duration of the study, the analysis of the data, and the preparation of this thesis.

Further appreciation is extended to Dr. I. T. Omtvedt, Professor of Animal Science, Dr. D. G. Wagner, Associate Professor of Animal Science, and Dr. D. R. Gill, Extension Livestock Nutritionist, for their suggestions and assistance in the preparation of this manuscript.

The author is grateful to his fellow graduate students for their comments and encouragement throughout the course of this study. A special vote of thanks is extended to Andy Boston for his helpful suggestions in the statistical analysis of the data.

The contribution of the author's brother, Lynn Lancaster, in helping with the calculations for the analysis of the data is greatly appreciated.

Most special appreciation is extended to the author's wife, Teresa, for typing the rough draft of this manuscript and for her endless understanding and encouragement during the course of graduate study. The author also expresses appreciation to his one year old daughter, Lisa.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Increasing per capita consumption of beef with an ever decreasing land mass for grazing has stimulated concern about the shortage of forage for beef production. With this situation existing, the forage available may be needed to maintain the cow herd rather than using a portion of it to grow out feeder-cattle prior to placing them in the feedlot for finishing.

Concern has been expressed that weaning calves placed directly in feedlots on high concentrate diets do not have the necessary time needed to grow and develop structurally to produce a desirable carcass which will be acceptable to the packer and consumer. The purpose of this study was to compare feedlot performance and carcass composition of calves placed directly on a finishing ration with those allowed a growth period prior to entering the finishing phase.

CHAPTER II

REVIEW OF LITERATURE

In reviewing the literature only a limited number of studies were found in which the experimental procedures were conducted under conditions similar to this study. However, there were a considerable number of studies that provide evidence concerning some of the basic biological phenomena involved.

Studies Directly Relevant to this Experiment

Oltjen, Rumsey and Putnam (1971) studied forty-eight Hereford steer calves, averaging 239 kilograms. The steers were removed from summer pasture, implanted with 24 milograms of diethylstilbestrol and randomly divided into four groups of 12 steers each. Adjustment from grazing to the experimental diets was accomplished in 21 days. Initially, two groups received the concentrate diet (A) and two groups received the pelleted forage diet (B). After 77 days, one concentrate group was switched to forage and one forage group was switched to concentrate during a 14-day transition period. The four groups were then fed for an additional 77 days. The four treatment diets for the first 77 and the last 77 days were designated AA, BB, AB, and BA for continuous concentrate, continuous forage, concentrate followed by forage and forage followed by concentrate, respectively. The steers receiving the all concentrate diet throughout the study were slaughtered at the end of the 168-day feeding period; but since it was desirable to slaughter all steers at a similar weight the BA steers were continued on diet A and were slaughtered at 189 days, AB at 196 days and BB at 203 days. Results are presented in Table I. Steers fed only the all concentrate diet gained faster than steers fed the two diet combinations or those fed only the all forage diet. Also, the steers fed the all concentrate diet were more efficient. Steers on the BA feeding regime, however, came close to the all concentrate group during period 2 in converting feed to pounds gained.

Dahmen, Keith, and Bell (1962) found that steers fed a low level of concentrates for the first 140 days of feeding had lower slaughter grades than steers fed a higher level of concentrates. Also, the high concentrate group had the highest degree of marbling at the time of slaughter.

Winchester and Howe (1955) used six pairs of monozygotic twin steers to study the relative effects of continuous and of interrupted growth. One member of each pair was fed at a level in which growth was retarded and the other was fed liberally. Retarded animals were fed at either a maintenance or moderate energy level ration. Each steer was slaughtered when it reached a weight of about 1000 pounds. In most cases the retarded animals reached slaughter weight from 10 to 20 weeks later than did their co-twins, but both attained their weight on approximately the same intake of energy. They concluded that under conditions of feed scarcity beef cattle between the ages of 6 and 12 months can be carried on a low energy level, as low as maintenance if necessary. This can be accomplished if the nutritional needs other than those for energy are supplied, without loss later in efficiency of feed utilization, meat quality, or in the proportion of lean meat, as compared with fat and bone in the carcass.

Dunbar, Addis and Lofgreen (1970) studied the effects of "backgrounding" or retarding growth on 45 head of #1 Okie steers. The steers

TABLE I

FEEDLOT PERFORMANCE OF STEERS FED HIGH CONCENTRATE OR HIGH ROUGHAGE DIETS BY PERIODS[1]

Item	Diet			
	A,A	B,B	A,B	B,A
No. Steers	12	12	12	12
Period 1 (0-77 days)	A	B	A	B
Daily gain, kg.	1.44	1.08	1.30	1.07
Feed/gain ratio	4.89	8.28	5.36	8.81
Transition (77-91 days)	none	none	A B	B A
Period 2 (91-168 days)	A	B	B	A
Daily gain, kg.	1.20	1.06	0.95	1.25
Feed/gain ratio	6.32	11.43	11.43	6.66
Total study (0-168 days)	AA	BB	AB	BA
Daily feed intake, kg.	7.26	10.59	8.69	8.28
Daily feed intake, % body weight	2.15	3.23	2.64	2.44
Daily gain, kg.	1.27	1.05	1.09	1.11
Feed/gain ratio	5.71	10.06	7.98	8.14

[1]Oltjen, et al. (1971)

were randomly allotted to one of three treatments and averaged 397 pounds initially. Group 1 was started immediately on a high energy ration. Group 2 was fed a backgrounding ration until the average weight was approximately 500 pounds then changed to the high energy ration. Group 3 was fed a backgrounding ration until the average weight was approximately 600 pounds then changed to the high energy ration (Table II).

TABLE II

COMPARISON OF STEERS FED HIGH ENERGY RATIONS FOR THE FINAL 154 DAYS[1]

Item	Group 1	Group 2	Group 3
70-day weight, lb.	640	634	586
224-day weight, lb.	1027	1053	995
154 day gain, lb.	387	419	409
Daily feed, lb.	15.84	16.84	16.73
Daily gain, lb.	2.51	2.72	2.66
Feed per lb. of gain, lb.	6.31	6.19	6.29

[1]Dunbar, et al. (1970)

For the entire 224 day study feed conversion favored group 1 with the poorest being made by group 3. Total gain and daily gain were the highest for group 2 which allowed them to catch group 1 in weight after 112 days on trial. In comparing the last 154 days of the study when all three groups were on the high energy ration, group 2 and 3 which were backgrounded for 28 and 70 days, respectively, consumed more feed than group 1 and gained somewhat more. The animals in group 2 showed a better feed conversion than either of the other groups, with little difference between groups 1 and 3. In comparing the three groups on composition of the liveweight gain, water and ash showed little difference while protein was the same in all three groups and fat was observed to be the most variable with the highest percent occurring in group 2 and the least amount being observed in group 1.

Studies Relating to the Basic Biological Phenomena Involved in this Study

Animals that have previously been on a restricted diet and then switched to a normal level of feeding generally can reach the same weight and size as continuously fed animals with little loss in over-all efficiency. This phenomenon is commonly known as compensatory growth. It is described as the ability of an animal to recover rapidly in growth following a period of under nutrition.

Occurrence of Compensatory Growth

In a pioneering study of retarded growth, Waters (1908) studied the effects of steers fed a maintenance or submaintenance ration. He stated that, "an animal that is below the normal size at a given age because of poor nourishment apparently had the capacity, when liberally fed, to compensate for this loss in a measure at least, by an increased rate of gain." He showed that underfed steers continued to grow in skeletal size and at the same time decreased in fat tissue, and that they could recover and reach normal mature weights and heights during a subsequent period of full feeding. Osborne and Mendel (1915 a,b) observed that growth could be continued at an accelerated rate after a long period of restriction in experiments conducted with rats. These laboratory animals were maintained at constant weight for periods up to 500 days. When offered unrestricted food, these rats grew at abnormally rapid rates and achieved their normal mature size. Eckles and Swett (1918) reported that there was a negative relationship between wintering plane of nutrition and summer pasture gains of dairy heifers. They concluded that in general the heifers had the ability to recover from the effects of a period of under nutrition, but that if the restriction is too severe the mature size may be permanently reduced. This was substantiated more recently by Thomas (1952) who found that Angus and Hereford heifers wintered at a low level made less gain than either medium or high level heifers fed during winter, but made the most gain on grass the following summer. Black, Queensberry, and Baker (1940) wintered steers on three different planes of nutrition. They found that those wintered on a low plane made the lowest winter gains and the highest summer gains. Similar results have been reported by Joubert (1956), and Nelson and Campbell (1954).

Stearns and Moore (1931) found compensatory growth rates occurring in man. They showed that compensatory growth rates in children during the first nine months of re-alimentation could be as much as nine times the normal rate of weight increase and four times the normal rate of increase in height, when such children were offered an ample balanced diet after a period of severe malnutrition. Meyer, et al. (1965) used weaning beef steers to investigate the influence of various levels of energy intake during the growing phase on subsequent compensatory growth responses in the feedlot. He found that compensatory growth was demonstrated following a low energy intake period, even though the animals were re-alimented at different planes of nutrition. Not only did compensatory growth response occur in terms of empty body weight gain or caloric gain, but the carcass characteristics, fat content, back-fat thickness, marbling score and ribeye area were enhanced. Palsson (1955) summarized the findings of previous workers and states that any part, organ or tissue of an animal retarded in its growth by restricted nutrition exhibits a great recuperative capacity when that restriction is removed. Most parts, organs and tissues will recover completely from the effects of retardation if the under nutrition has not been too severe.

Effect on Feed Intake

There have been numerous reports published noting the marked increase in the appetite of animals during realimentation (Sheehy and Senior, 1942; Quinby, 1948; Winchester and Howe, 1955; Wilson and Osbourn, 1960).

The development of the alimentary tract of animals has been shown to be only very slightly retarded by under nutrition, and to be related to chronological age rather than to the physiological age of the animal (Trowbridge, et al. 1918; McMeekan, 1941; Wallace, 1948; Palsson and Verges, 1952; Wilson, 1954).

Quinby (1948) studied the food and water economy of the young rat during chronic starvation and recovery and found that food intake during recovery was greatly increased. Meyer, et al. (1965) reported that steers previously restricted for 172 days on a low energy intake consumed more feed relative to body size during subsequent full feeding than did those previously fed a medium to high energy intake. However, Meyer and Clawson (1964) found that the feed intake per unit of metabolic weight was similar for restricted, full-fed and continuously full-fed rats and sheep and concluded that feed intake was not a factor in compensatory growth in their study.

Efficiency of Growth

Watson (1943) concluded that any period of nutritional restriction in an animal's life inevitably results in a decrease in the lifetime efficiency in the production of human food.

Meyer and Clawson (1964) fed rats and sheep 20, 36, 52, 68, 84, and 100% of a full feed for 21 days (rats) or 42 days (sheep). Following this initial feeding period 1/3 of the animals on each restricted ration were fed *ad libitum* until the same amount of total feed was consumed as full-fed controls received during the previous period, and 1/3 were fed *ad libitum* until they attained a body weight equivalent to that attained by continuously full-fed controls during the first peiod. Both restricted rats and sheep fed the same total amount of feed as full-fed controls were not able to reach the same body weight as controls. This would be expected since animals on a restricted diet when changed to a full-fed diet do not have as much feed above maintenance requirements in which to gain weight as the controls which were full-fed from the beginning.

Sheehy and Senior (1942) examined the effect of periods of slow growth upon the over-all efficiency of weight gain in steers from 700 to 900 pounds. They found that the additional feed required by the restricted groups to reach equivalent weights to the unrestricted groups was greater than the amount of food saved during the restriction period. Henrickson (1965) observed 88, 8-month old Hereford steer calves that initially averaged 480 pounds and were fed to gain rapidly for 400 pounds on a 95.5% concentrate ration in the feedlot reached slaughter weight in a shorter period and required less feed per pound of gain than calves fed on a ration containing 15.6 and 25.5% less concentrates.

However, Winchester and Howe (1955) found that six pairs of twin beef steers subjected to a 6-month period of energy restrictions, followed by _ad libitum_ feeding until each steer reached 1000 pounds achieved the same weight without consuming significantly more food than animals reared on a good diet throughout life.

Two important differences exist between the experiments conducted by Sheehy and Senior and those of Winchester and Howe. Sheehy and Senior allowed their experimental animals to lose weight during the restriction period. Also, Sheehy's animals were rationed during the period of re-alimentation while Winchester's steers were fed _ad libitum_. According to Wilson and Osborn (1960) these differences in experimental procedure perhaps account for the different results. They also stated that a restricted and a re-alimentated animal was no less efficient than a continuously grown animal, providing it does not lose weight and was allowed to express its increased appetite during re-alimentation by _ad libitum_ feeding. Meyer, et al. (1956) found that rats restricted for 21 or 28 days and then full-fed made total gains similar to controls when given an equal total food intake, even though total time on feed was longer.

It has also been shown that animals can compensate for growth restriction due to reduced protein intake without loss in overall feed efficiency. Carrol, et al. (1964) fed low protein isocaloric rations to 40, 410 pound heifers in a paired feeding experiment. For 108 days postweaning, one member of each pair was fed a maintenance level of energy and a submaintenance level of protein (4.5% CP) and the other member was fed the same level of energy and a liberal allowance of protein (14.1% CP). At the end of this period, both members were switched to a liberal ration and fattened for 110 days before slaughtering. Eight heifers selected at random were slaughtered at the beginning of the study. The remaining 32 calves were divided into 16 pairs and at the end of the restricted period eight pairs were again selected at random to be slaughtered to follow energy changes. At the end of the maintenance period, the heifers restricted in protein had a higher body fat content and reduced feed efficiency for the period. The lowered feed efficiency was attributed to the higher caloric value of weight gains. Compensatory growth during liberal feeding was great enough that the differences in final weight and overall efficiency of energy utilization within pairs were not significant.

Winchester, Hiner and Scarborough (1957) fed various combinations of energy and protein levels to restrict the growth of 10 pairs of monozygotic twin beef cattle of both sexes with one member of a pair receiving a different ration than its co-twin. The various combinations of energy and protein were: maintenance energy and 2.4, 6.5, and 12.4 percent digestible protein; energy sufficient for one pound of gain per day 6.7, 10.4, and 13.7 percent digestible protein; or energy sufficient for two pounds per day gain and 6.5 and 11.4 percent digestible protein. The calves were restricted between the ages of six and 12 months and were then switched to a good growing ration. During the restricted period, animals on the lowest level of protein (2.4% DP) lost weight, and those animals fed a caloric intake above maintenance gained weight in direct proportion to the level of protein in the ration. All restricted animals, however, compensated during liberal feeding and the overall feed efficiency of co-twins was similar despite the extremely drastic restrictions in nutrition imposed on one member of the pair during the restricted period. Likewise, Fox, et al. (1972) placed steers on a restricted ration for 154 or 190 days and were then full-fed until they reached the same final weight as continuously full-fed steers. He found that compensatory steers gained significantly faster and required significantly less feed per pound of gain during the full feeding period than did the controls.

Composition of Gain and Final Body Composition

Sheehy and Senior (1942) concluded that restricted, full-fed animals compensate for the period of restriction and reach the same final weight as continuously fed animals due to more protein and less fat in the gain during recovery, and therefore require less energy per unit of weight gain and have a lower final body energy content.

Hammond (1932), McMeekan (1940, 1941), and Wilson (1952, 1954) have shown that all tissues are subjected to a wave of high growth in the following order: nervous tissue, skeletal tissue, muscular tissue and adipose tissue. Retardation of the rate of growth has the greatest effect upon the late maturing tissues and regions of the body. Palsson (1955) summarized other workers results and concluded that restricted nutrition, during any age interval from the late foetal stage until growth ceases, has an increasing retarding effect on the different tissues and regions of an animal's body in the direct order of maturity; the earliest maturing parts or tissues being least, and the latest maturing ones most affected. Animals subjected to periods of submaintenance utilize their tissues for maintenance in the reverse order of maturity, and the areas depleted are, firstly, the late maturing regions and then in reverse order of maturity. Work done by Stuedemann, et al. (1968) supports the theory of growth intensity. He found using Hereford steers from birth to 8 months of age that upon slaughter the relative amounts of lean, fat and bone tissue produced were directly influenced by the level of nutrition imposed upon them. As the level of nutrition decreased significantly less lean, fat and bone were produced. The relative retardation of growth was greatest in fat tissue followed by lean and bone respectively.

Meyer, et al. (1965) found that steers given a high energy intake immediately after weaning and continued to a low choice finish have the highest body weight, empty body weight, and carcass weight but make equal energy gain and have a higher carcass fat, lower carcass protein and a smaller ribeye. The steers in this study had been fed a high energy level continuously, a high energy level following 172 days on a low or medium level, or a high energy level following 172 days on a low energy level plus 124 days on a liberal, medium, or low pasture level. The highest fat content of empty body weight gain was in steers given the high energy intake immediately after weaning or the low energy intake for 172 days followed by the high energy intake.

Meyer, Lueker, and Smith (1956), however, reported a greater proportion of fat at slaughter in the bodies of rats restricted in total food intake for 28 days and then full-fed than in continuously fed controls. Meyer and Clawson (1964) found that during recovery both rats and sheep had a higher percent fat and lower percent protein in the empty body weight gain. Fox, et al. (1972) concluded that compensatory steers deposit relatively more protein and less fat than controls during the first part of the full-feeding period but deposit relatively more fat than controls during the last part of the full-feeding period.

Most workers have found little difference in total body composition between restricted full-fed and continuously full-fed animals and none on a fat-free basis. Winchester and Howe (1955) and Winchester and Ellis (1957) found no difference in final carcass composition between restricted full-fed and continuously full-fed steers. Lawrence (1964) reported that a longer period of time was required for previously restricted steers to reach 1000 pounds than continuously fed controls. There was little difference in dissectable muscle, fat, and bone, but there was a tendency for full-fed steers to have a higher percent of fat. Carroll, et al. (1964) found no difference between restricted, full-fed and continuously full-fed cattle in final weight or caloric value of the carcass. Hill (1967) severely restricted five steers during the winter, then full-fed them for 22 weeks and compared the chemical composition of the muscles from these steers to five steers full-fed continuously. Within each muscle there were no significant differences in moisture, intramuscular fat, total protein, ash, intramuscular collagen or Warner Bratzler shear values.

Effect on Skeletal Development

Waters (1908) reported that after eight months of maintenance steers had increased in height by 10% and in length of head by six to 19% while full-fed controls had increased in height by 13 to 17% during this same period. He concluded that a steer can be held at maintenance and still increase in skeletal size while losing body fat. It was also observed that height growth continued at a more rapid rate than width of hip under maintenance feeding. Muscle fiber diameter was reduced under submaintenance and that there was no further increase in height or length of bone after fat reserves were depleted. Trowbridge, Moulton, and Haigh (1918) in working with steers observed that body fat rapidly decreased with increasing time on maintenance and severity of restriction and the external fatty tissue lost its fat more rapidly than other parts of the body, although fat continued to be stored in the skeleton. They concluded that skeletal growth occurred at the expense of fat and protein from the soft parts of the body. Similar results were obtained by Carroll, et al. (1963). Palsson and Verges (1952) found that different organs, tissues and anatomical regions were retarded by restricted feeding in direct order of their growth intensity. Lambs raised on a high or low plane of nutrition from the third month of foetal life were slaughtered at birth, nine weeks or 41 weeks of age. Post natal growth tissues were affected in the order of increasing growth intensity with age. Thus the earlier maturing tissues had first priority on the available nutrients. Lush, et al. (1930) studied the growth of range cattle from birth to 30 months of age and found that cattle under range conditions continue to grow in skeletal size during the winter and decrease in body fat. Guenther, et al. (1965) found that the rate of skeletal development was the same whether steers were fed on a low or a high plane of nutrition and concluded that skeletal development was accomplished early in life and was related more to animal age and duration of feeding time than to the nutritional treatments imposed.

Palsson and Verges (1952), however, found that lambs reared to equal final weights on different planes of nutrition did not have equivalent bone structures. Lambs were reared on a high plane continuously, high plane for six weeks then low plane, low plane for six weeks then high plane or on a low plane throughout. All were slaughtered at final body weights that would yield 30 pound carcasses. Those fed on a low plane throughout had lighter bones due to less bone thickness and muscle was better developed in high-low and low-low groups, whereas, fat development was more highly developed in low-high and high-high groups. Stuedemann, et al. (1968) reported that steers 8 months old, subjected to a high level of nutrition which included creep feeding, had higher dressing percentages, carcass grade and skeletal scale than those on a lower level of nutrition. McCay, Crowell and Maynard (1935) found that retarded rats cannot attain a body size equal to continuously grown controls.

To the contrary, Osborne and Mendel (1915, 1916) found that resumption and completion of growth in rats could be readily obtained after more than 550 days of restriction and the size or age at which the restriction was imposed did not alter the capacity to resume growth and reach a normal mature body size. Winchester (1955) found that even though calves made no weight gain during the restricted period skeletal growth continued and when placed on full feed the growth of restricted full-fed cattle equaled or exceeded continuously full-fed co-twins. Differences in body measurements were small when the co-twins were of about equal weight at the time of slaughter.

Possible Recovery Mechanism

Recovery has two components. First, a prolongation of the period of growth of the animal and secondly, an increase in the rate of weight gain when the animal is re-alimentated. There is ample evidence to support the thesis of prolonged growth. Results from several species of farm animals have been summarized in Table III compiled by Wilson and Osbourn (1960).

TABLE III

DIFFERENCES IN TIME TAKEN BY ANIMALS UNRESTRICTED IN DIET, AND RESTRICTED AND RE-ALIMENTATED, TO REACH A GIVEN STAGE OF GROWTH[1]

Animal (a)	Final Live Weight (b)	Age and Weight at Re-alimentation (c)	Time Taken by Controls to Final Weight, Days (d)	Time Taken by Restricted Group to Final Weight, Days (e)	Percentage Difference Between (e) and (c) (f)	Reference (g)
Pig	200 lb.	112 days (50 lb.)	180	240	33.3	McMeekan (1940)
Fowl (male)	1700 g.	70 days (700 g.)	98	112	14.2	Wilson (1952)
Fowl (female)	1250 g.	70 days (550 g.)	91	112	24.2	
Sheep (male)	60 lb.	42 days (20 lb.)	63	98	38.4	Palsson and Verges (1952)
Sheep (female)	60 lb.	42 days (20 lb.)	63	126	100.0	
Goat (male)	33 lb.	112 days	140	238	70.0	Wilson (1957 b)
Goat (female)	33 lb.	140 days	210	252	20.0	
Fowl (group A)	1100 g.	60 days	64	75	17.2	Osbourn and Wilson (1960)
Fowl (group B)	1100 g.	60 days	64	75	17.2	

[1] Wilson and Osbourn (1960)

Perhaps the postulation presented by Maynard and Loosli (1969) can help explain the physiological changes which occur during restriction and recovery. They stated that in stunting, cells may be depleted yet remain in outline capable of being filled in later without complete rebuilding. The rapid increase in weight which follows retardation may be due to a considerable extent a replacement of lost fat and this process may take place more rapidly than true growth. The actual suppression of growth may be less than the weight measures indicate. Cellular development may proceed in important ways yet not be reflected in any increase in weight.

Protein synthesis and accumulation during recovery was found to be similar to normal growth in the young rat according to Howarth and Baldwin (1971). They concluded that a compensatory acceleration in growth of the protein component of muscle did not occur, but according to Wilson and Osbourn (1960) is caused by growth of internal organs or adipose tissue.

CHAPTER III

MATERIALS AND METHODS

A 194-day feeding trial was conducted to compare feedlot performance of 205 day old calves placed directly on a high concentrate finishing ration with calves allowed a growing period of 76 days before being placed on the finishing ration. The 94 choice Angus steers initially allotted to this experiment were the progeny of 10 sires involved in a progeny test as part of the beef cattle breeding project presently being conducted at Oklahoma State University. Half of the progeny from each sire were randomly allotted to each of the two treatment groups in such a way that the overall actual weaning weights were quite similar for the two treatments. The distribution of steers by sire is presented in Table IV.

The steers were weaned at an average age of 205 days at the Lake Carl Blackwell range on September 29, 1970, and were transported to the Fort Reno Livestock Research Station where they were weighed, measured for height at the withers, immediately placed in the feedlot and started on the experimental rations. Three animals died while on test (one on the grower ration and two on the finishing ration) and their performance data were excluded from the analysis. The final analysis was completed on 45 calves on the grower ration and 46 calves on the finishing ration. The composition of the rations and supplements are presented in Tables V and VI, respectively. The rations were fed *ad libitum* during the 194

TABLE IV

DISTRIBUTION OF STEERS BY SIRE

Sire No.	Grower Ration Steers	Finishing Ration Steers
0805	6	6[1]
0814	5	4
0818	4[1]	5
0841	5	5
0842	3	3
9805	4	4[1]
9808	4	5
9837	5	6
9839	5	5
9840	5	5
Totals	46	48

[1]One steer died during the feedlot trial.

TABLE V

COMPOSITION OF RATIONS

Ingredient	Feed Costs for Economic Evaluation (Cost/Cwt)	Amount in Percent	
		Grower Ration	Finishing Ration
Alfalfa Hay	$ 1.80	84	8
Dry Rolled Milo	2.30	5	78
Wheat Straw	1.00		4
Molasses	1.75	6	5
Supplement (No. 1)	3.70	5	
Supplement (No. 2)	4.74		5
	Total	100	100

TABLE VI

COMPOSITION OF PELLETED SUPPLEMENTS

Ingredient	Amount in Percent	
	Supplement 1	Supplement 2
Salt	8.000	8.000
Dicalcium Phosphate	6.000	
Calcium Carbonate		10.000
Stilbesterol, 2 g/lb.	0.625	0.625
Aureomycin, 10 g/lb.	1.250	1.250
Vitamin A[1]	0.625	0.625
Trace Minerals	0.500	0.500
Wheat Middlings	83.000	
Urea, 45% N		12.000
Soybean Oil Meal, 44% CP		67.000
Total	100.000	100.000

[1]Four million I. U. per lb.

day feeding trial. The steers were fed in two adjoining pens that opened to the south from the feeding barn.

The feeding trial was divided into two periods. The first consisted of 76 days during which one set of steers was fed the grower ration containing supplement 1 while the other set of steers was placed directly on a high concentrate finishing ration containing supplement 2 throughout the feeding period. Steers fed the finishing ration were allowed an adjustment period of 26 days during which the milo level was gradually increased from 50 to 78 percent. Final weight and wither height were measured at the end of the first period. Average daily gain and feed efficiency, expressed as pounds of feed per pound of gain, were subsequently determined. The second period consisted of the remaining 118 days of the feeding trial. During the second period the steers originally on the grower ration were allowed an adjustment period of the first 21 days in which the milo level was gradually increased from 50 to 78 percent. From this point until the end of the trial both sets of steers were on the same finishing ration containing supplement 2. Final feedlot weight was taken for each of the 91 steers that completed the feedlot trial. From this information average daily gain and feed efficiency were determined for the last period of 118 days as well as for the entire feeding period of 194 days.

Carcass data were obtained on all steers involved in this study. In order to obtain ^{40}K counts prior to slaughter and carcass specific gravity for the purpose of comparing carcass composition a random sample of 20 steers from each treatment group was slaughtered at the OSU Meat Laboratory. The balance of 51 steers was slaughtered at a commercial packing plant in Oklahoma City. Because of the number of animals to be slaughtered at the OSU Meat Laboratory, it was necessary to have two separate slaughter groups. To obtain the two different slaughter groups the 91 steers were divided into two groups based on a visual appraisal as to the degree of finish. Twenty steers (10 from each treatment group) were randomly selected from the half having the highest degree of finish for the first slaughter group which was slaughtered on April 14, 1971. Twenty steers (10 from each treatment group) were then randomly selected from the half having the lower degree of finish to be slaughtered two weeks later. The remaining 51 steers were slaughtered in a commercial packing plant at Oklahoma City at the same time as the first group of steers was slaughtered at the OSU Meat Laboratory.

The following data were collected on the carcasses from each of the 91 steers: hot carcass weight, ribeye area, single fat covering, average fat covering, carcass length, carcass depth, Armour tenderometer reading, estimated percent kidney, heart and pelvic fat, carcass conformation, carcass grade and marbling. From the data collected cutability was then calculated using the single fat prediction equation proposed by Murphey, et al. (1960). USDA carcass conformation and grades were converted to the following numberical designations: high choice 12, average choice 11, low choice 10, and high good 9. Marbling score equivalents were moderate 7, modest 6, small 5 and slight 4.

Carcass length and depth was measured by the procedure described by Naumann (1951) in which length is determined by measuring from the anterior edge of the first thoracic vertebra to the anterior edge (lowest point) of the aitch bone. Carcass depth was measured from the dorsal side of the spinal canal at the 5-th thoracic vertebra to the ventral side of the sternum with the tape being held parallel to the floor.

The Armour tenderometer consists of a battery operated probe assembly and a readout unit. The probe assembly includes 10 penetration needles, each three inches long, mounted on a manifold which is in turn attached by cable to an electronic strain gauge. The 10 pointed needles penetrate the longissimus dorsi muscle between the 12-th and 13-th thoracic vertebrae. Readings were taken on the chilled carcasses 24 hours after slaughter. Small tenderometer readings supposedly indicate a more tender cut than those with larger readings.

Each of the 40 steers slaughtered at the OSU Meat Laboratory were evaluated by the ^{40}K counter at the OSU Live Animal Evaluation Center prior to being slaughtered. In addition to the normal carcass measurements, body composition was estimated from calculated carcass specific gravity on the steers slaughtered at Stillwater. Each of the 40 steers evaluated at the Live Animal Evaluation Center were counted after a 24-hour shrink just prior to slaughter according to the procedure described by Frahm, et al. (1971).

Carcass specific gravity was calculated for the right side of each of the steers slaughtered at Stillwater by dividing the carcass weight in air by the total carcass volume. According to Hedrick (1967) estimation of the volume can be made using the Archimedean principle that the body immersed in water loses weight by an amount equal to the displaced water. Therefore, the volume of the carcass is the difference between the weight in air and the weight when completely submersed in water. Thus the formula can be simplified to the form of:

$$\text{Carcass specific gravity} = \frac{\text{Carcass weight in air}}{\text{Carcass weight in air} - \text{Carcass weight in water}}$$

where weight in air is the chilled carcass weights of both quarters weighed separately on a Toledo spring balance scale to the nearest one-tenth of a pound and the weight in water is the pooled underwater weights of both quarters weighed in water at 34° F. The underwater weight was determined with a Toledo tortion beam balance to the nearest gram.

The data were analyzed by utilizing the t-test to compare treatment means as described by Snedecor and Cochran (1967). Standard errors were computed for each of the means tested.

The feedlot performance and carcass traits that were found to be significantly different for the two treatments were subjected to a two factor analysis of variance (Steel and Torrie, 1960) to determine the presence of any treatment by sire interactions. The performance traits analyzed were final weight at the end of the first period, change in wither height, average daily gain for the first period and average daily gain for the last period. The carcass traits analyzed were average fat covering, carcass grade and marbling score.

The form of the analysis of variance is shown in Table VII. The mathematical model employed for each of the traits analyzed was:

$$Y_{ijk} = u + T_i + S_j + (TS)_{ij} + E_{ijk}$$

where,

Y_{ijk} = observation on the k-th steer from the j-th sire group and the i-th treatment.

u = overall mean

T_i = effect of the i-th treatment (i = 1, 2)

S_j = effect of the j-th sire (j = 1, 2, ..., 10)

$(TS)_{ij}$ = effect for the interaction between the i-th treatment with the j-th sire

e_{ijk} = random effect for the ijk-th observation.

TABLE VII

FORM OF THE ANALYSIS OF VARIANCE

Source	df
Treatment	1
Sire	9
Treatment x Sire	9
Residual	71
Total	90

Correlation coefficients as described by Steel and Torrie (1960) were calculated for carcass specific gravity with live ^{40}K count, ^{40}K count per pound of live weight, ^{40}K count per pound of hot carcass weight and average fat covering on those animals slaughtered at Stillwater on a within slaughter date and treatment basis. The within group correlations were not found to be significantly different using the z-transformation procedure described by Snedecor and Cochran (1967), thus the correlations were pooled over the treatment and time of slaughter groups.

During the collection of the carcass data it became apparent that the steers slaughtered at the OSU Meat Laboratory seemed to have a smaller ribeye area than the steers slaughtered at the commercial packing plant. In order to ascertain whether this difference was significant a two-factor analysis of variance was conducted on certain of the carcass data from the 20 steers in the first slaughter group at the OSU Meat Laboratory and 26 steers slaughtered at the commercial packing plant at the same time. This set of 46 steers were those separated out as having a higher degree of finish for the purpose of determining the slaughter groups for the OSU Meat Laboratory. The carcass traits analyzed were: hot carcass weight, ribeye area, average fat covering, single fat covering, estimated percent kidney, heart and pelvic fat, marbling, cutability, carcass conformation, and carcass length.

In addition to the analysis of feedlot performance and carcass traits, an economic evaluation of the feedlot performance was determined for the two treatments imposed utilizing the feed costs shown in Table V. These feed costs were determined on the basis of prevailing feed prices at the time the study was conducted. Feed cost per pound gained was calculated for the live animals that finished the test to effectively compare treatments. A customary yardage fee of 12 cents per head per day was also included in making these computations.

CHAPTER IV

RESULTS AND DISCUSSION

Treatment Comparisons

Feedlot Performance

Treatment means, standard errors and differences between treatment means are presented in Table VIII for the two nutritional treatments involved in this study.

At the end of the first period of 76 days, the steers on the high concentrate finishing ration were significatnly heavier and had higher average daily gains than the steers on the high roughage grower ration. Also the steers on the finishing ration had a 1.22 pound advantage in feed efficiency. This would appear to be a real difference, although it was not possible to make a statistical test of significance because feed efficiency was determined on a group rather than individual basis. Change in wither height during the first period was significantly greater ($P<.01$) for the steers on the finishing ration, indicating that structural growth occurred at a faster rate on the finishing ration than on the grower ration. This is in agreement with Stuedemann, et al. (1968) who found that the degree of skeletal development depended on the level of nutrition being fed.

The last period, which consisted of the last 118 days of the feeding trial, resulted in typical compensatory growth characteristics being

TABLE VIII

MEANS AND STANDARD ERRORS FOR FEEDLOT PERFORMANCE (194 DAYS)

Traits Measured	Grower Ration Steers	Standard Error	Finishing Ration Steers	Standard Error	Difference (Finishing-Grower)
Number of steers	45		46		
Initial weight, lbs.	435	7.81	430	7.32	-5
Final weight, first period, lbs.	603	8.43	646	8.80	43 **
Initial wither height, in.	37.16	0.22	37.00	0.26	-.16
Change in wither height, first period, in.	2.55	0.16	3.17	0.18	0.62**
ADG first period, lbs.	2.22	0.05	2.84	0.06	0.62**
Final feedlot weight, lbs.	982	14.34	980	11.83	-2
ADG last period, lbs.	3.21	0.08	2.83	0.06	-.38**
ADG total, lbs.	2.82	0.06	2.83	0.04	0.01
Lbs. feed/lb. gain, first period	6.74		5.52		-1.22[1]
Lbs. feed/lb. gain, last period	6.49		6.30		-.19[1]
Lbs. feed/lb. gain, total	6.57		6.00		-.57[1]

[1]Statistical tests of significance were not possible since feed efficiency was determined on a treatment group basis.

**Significant (P<.01)

exhibited by the steers previously fed the grower ration. This was expressed in a 0.38 pound advantage in average daily gain. It should be noted, however, that although the finishing ration steers did not gain as rapidly as the grower ration steers during the final feedlot period, they were slightly more efficient in terms of pounds of feed required per pound of gain. This is in contrast to most workers findings but does however support the conclusions of Watson (1943), Sheehy and Senior (1942) and Oltjen, et al. (1971).

The most striking result of the feedlot performance was that average daily gain for the total feeding trial and final feedlot weight were not significantly different for the two treatments. Even though total feedlot gain was essentially the same for the two treatments, the group of steers on the finishing ration for the entire feedlot period was slightly more efficient in terms of pounds of feed required per pound of gain. The 1.22 pound advantage in feed efficiency for the finishing ration steers during the first period and 0.19 pound advantage during the last period resulted in a 0.57 pound advantage over the total feeding trial. This would be expected since the steers fed the high concentrate diet for the entire trial would have more net energy available for production than those fed the grower ration prior to the finishing ration.

Carcass Data

Of the 51 steers slaughtered at the commercial slaughter plant at Oklahoma City, 26 were a random sample from the group of steers subjectively evaluated as having a higher degree of finish and 25 were a random sample from the group of steers evaluated as having a lower degree of finish. The higher finish group had a heavier carcass weight (622 versus

576 pounds) and more fat cover (0.80 versus 0.71 inches). However, they had a lower marbling score (4.88 versus 4.96) which consequently resulted in a lower carcass grade (9.69 versus 10.04). The separation of the steers according to degree of finish was for the sole purpose of determining the steers to be slaughtered at the OSU Meat Laboratory on the two different slaughter dates. It should not influence the comparisons between treatment groups because steers from both treatment groups were represented in nearly equal number for both locations and time of slaughter.

Treatment means, standard errors and treatment differences for each of the carcass traits measured are given in Table IX. In general, the carcass traits were similar for the two treatment groups. Although the final feedlot weight was essentially the same for the two groups, the hot carcass weight was 12 pounds heavier for the finishing-ration steers. However, this difference was not statistically significant. The finishing ration resulted in a larger amount of fat as indicated by significantly more fat over the 12-th rib (0.85 versus 0.73) and a higher marbling score (5.11 versus 4.58). Consequently, the finishing ration steers received a significantly higher carcass grade (10.02 versus 9.06).

The Armour tenderometer readings were not found to be significant. However, interpretation of the data in this study are inclusive in determining difference in tenderness as a result of the findings of Henrickson and Marsden (1971), and Dikeman, et al. (1972). They found the low correlations existed between the tenderometer and Warner Bratzler shear values and also, between tenderometer and taste panel observations.

Of the steers slaughtered at Stillwater, those on the finishing ration were 0.11 of an inch fatter at the 12-th rib. Although this is

TABLE IX

MEANS AND STANDARD ERRORS FOR CARCASS TRAITS

Traits Measured	Grower Ration Steers	Standard Error	Finishing Ration Steers	Standard Error	Difference (Finishing-Growth)
Number of steers	45		46		
Hot carcass weight, lbs.	589	8.42	601	7.23	12
Ribeye area, sq. in.	10.83	0.15	10.75	0.16	-.08
Kidney, heart and pelvic fat, %	2.87	0.07	3.02	0.07	0.15
Single measured fat, in.	0.59	0.03	0.67	0.03	0.08
Average fat covering, in.	0.73	0.03	0.85	0.03	0.12**
Carcass conformation	11.78	0.18	11.91	0.16	0.13
Carcass grade	9.36	0.16	10.02	0.18	0.66**
Marbling	4.58	0.13	5.11	0.13	0.53**
Cutability, %	49.25	0.25	48.53	0.29	-.72
Carcass length, in.	45.89	0.22	45.59	0.19	-.30
Carcass depth, in.	14.82	0.10	14.92	0.11	0.10
Armour tenderometer reading	17.18	0.49	17.34	0.41	0.16

**Significant (P<.01)

approaching significance, net ^{40}K counts per minute of the live animal and carcass specific gravity did not indicate any significant difference in body composition (Table X). Kraybill, et al. (1952) observed the correlation between body fat and specific gravity to be -.956 and that for specific gravity and water content was 0.984. To further substantiate the fact that specific gravity is a good measure of body composition, Garrett and Hinman (1969) reported correlation coefficients between carcass density and the chemical constituents of the empty body to be -.96, 0.93, 0.92 and -.95 for percent fat, water and nitrogen, and energy, kcal./gm., respectively.

An analysis of variance for the 91 head of steers that finished the feeding trial was calculated for final weight at the end of the first period, change in wither height, average daily gain for the first period and average daily gain for the last period. The results are shown in Table XI. The analysis of variance for average fat covering, carcass grade, and marbling score are shown in Table XII.

As previously indicated by the t-test, treatment effects were significantly different for all of the traits included in this analysis and most of the variation was due to treatment effects. Sire differences were significant only for carcass grade and marbling score which indicates this set of 10 sires were apparently genetically similar with regard to the other performance traits analyzed. This was not too unexpected since the 10 sires were a select group that was selected for progeny testing on the basis of either their superior weaning or yearling weight. Treatment by sire interactions were not found to be significant for any of the feedlot performance and carcass traits analyzed. From a genetics standpoint, the absence of treatment sire interactions indicate

TABLE X

CARCASS DATA FOR STEERS SLAUGHTERED AT THE OSU MEAT LABORATORY

Traits Measured	Grower Ration Steers	Standard Error	Finishing Ration Steers	Standard Error	Difference[1] (Finishing-Grower)
Number of steers	20		20		
Hot carcass weight, lbs.	581.50	9.50	598.00	11.50	16.50
Ribeye area, sq. in.	10.35	0.22	10.31	0.27	-.04
Single measured fat, in.	0.65	0.05	0.72	0.06	0.07
Average fat covering, in.	0.78	0.05	0.89	0.05	0.11
Carcass grade	9.25	0.23	9.70	0.21	0.45
Marbling	4.55	0.18	4.95	0.18	0.40
Cutability, %	48.74	0.46	47.88	0.55	-.86
Specific gravity	1.048	0.001	1.045	0.002	-.003
Live ^{40}K count, counts/min.	14,049.00	167.00	14,065.00	234.00	16.00

[1]Differences were not significant ($P < .05$)

TABLE XI

ANALYSIS OF VARIANCE FOR PERFORMANCE TRAITS

Source	df	Final weight 1st period MS	Change in wither height MS	Average daily gain first period MS	Average daily gain last period MS
Treatment	1	41,786**	8.86*	8.90**	3.25**
Sires	9	1,740	1.61	0.10	0.43
Treatment x Sire	9	3,833	0.96	0.12	0.15
Residual	71	3,533	1.33	0.17	0.22
Total	90	3,809	1.41	0.25	0.27

*Significant (P<.05)

**Significant (P<.01)

TABLE XII

ANALYSIS OF VARIANCE

FOR CARCASS TRAITS

Source	df	Average Fat Covering MS	Carcass Grade MS	Marbling Score MS
Treatment	1	0.32*	10.10**	6.41**
Sires	9	0.06	2.81*	1.55*
Treatment x Sire	9	0.04	0.90	1.12
Residual	71	0.04	1.18	0.64
Total	90	0.04	1.42	0.84

*Significant (P<.05)

**Significant (P<.01)

that it would be possible to accurately rank sires from a progeny test on either or both of the treatments imposed in this study.

Correlation Coefficients

Correlation coefficients for carcass specific gravity with ^{40}K count, ^{40}K count per pound of live weight, ^{40}K count per pound of hot carcass weight and average fat covering are presented in Table XIII. The group correlations appear to be very erratic which is not surprising since each group contained only a small number of observations. However, the within group correlations were not found to be significantly different and were therefore pooled over groups. The pooled correlation between total ^{40}K count and carcass specific gravity was fairly low (0.22). However, when ^{40}K count was evaluated as count per pound of live weight and count per pound of hot carcass weight, a higher association with carcass specific gravity was found to exist. The correlation coefficients were 0.59 for ^{40}K count per pound of live weight and 0.67 for ^{40}K count per pound of hot carcass weight when each were correlated with carcass specific gravity. This was not very surprising since evaluating ^{40}K count on a per pound basis would tend to reflect ^{40}K count and specific gravity as indicators of density.

Average fat covering showed a moderate correlation with specific gravity (-.48). This value is similar to the -.57 coefficient found by Cole, Backus and Orme (1960). Since specific gravity is so highly correlated with percent fat in the entire carcass, it would appear that the moderate correlation obtained from average fat covering with specific gravity suggests that measuring fat thickness at the 12-th rib is not a real good estimate of the fat content contained within the carcass.

TABLE XIII

CORRELATION COEFFICIENTS FOR WITHIN TIME OF SLAUGHTER

AND TREATMENT GROUP AND POOLED WITHIN GROUP

			Correlation Coefficient of Carcass Specific Gravity with:			
Treatment	Slaughter Time	No. of Steers	^{40}K Count	^{40}K Count per lb. of Live Wt.	^{40}K Count per lb. of Hot Carcass Wt.	Average Fat Covering
Grower Ration	1	10	0.55	0.22	0.23	-.39
	2	10	0.57	0.58	0.74	-.42
Finishing Ration	1	10	-.22	0.78	0.83	-.56
	2	10	0.30	0.69	0.68	-.57
Pooled		40	0.22	0.59**	0.67**	-.48**

**Significant (P<.01)

Therefore, even though average fat covering was significantly different in the two treatment groups compared specific gravity indicated no significant difference in total body fat content.

Effect of Slaughter Locations

The analysis of variance to determine the presence of a location of slaughter effect for certain carcass traits are presented in Table XIV. No treatment by location of slaughter interaction was found to exist for any of the traits analyzed. A significant treatment effect was present for average fat covering ($P<.01$) and cutability ($P<.05$). Location of slaughter was found to be significant ($P<.01$) for ribeye area, single fat covering, cutability, carcass conformation and carcass length. A location effect was also found to be significant ($P<.05$) for average fat covering and percent kidney, heart and pelvic fat.

The differences in carcass conformation and estimated percent kidney, heart and pelvic fat were probably due to different persons determining these subjective measurements. There is no apparent reason for the more objective measurement of ribeye area, fat covering and carcass length being significantly different since the two slaughter groups were random samples from the set of steers designated as the groups having a higher degree of finish and were slaughtered at the same time. Hot carcass weight was however, 29 pounds heavier for those slaughtered at the commercial packing plant (Table XV) and might partially explain the larger ribeye area obtained at that location. The only difference in the procedure for handling these steers was that the 20 ~~steers~~ slaughtered at the OSU Meat Laboratory were first evaluated by the ^{40}K whole body counter and were subjected to a longer shrinkage period and more stress

TABLE XIV

ANALYSIS OF VARIANCE FOR CERTAIN

CARCASS TRAITS FOR THE 46 STEERS

SLAUGHTERED AT THE SAME TIME

Source	df	Hot Carc. Wt. MS	Rib Eye Area MS	Ave. Fat Cover MS	Single Fat Cover MS	Percent KHP MS	Marb-ling MS	Cuta-bility MS	Carc. Conf. MS	Carc. Length MS
Treatment	1	1,729	2.64	0.32**	0.15	0.21	1.61	14.99*	0.07	1.72
Slaughter location	1	9,540	36.92**	0.17*	0.36**	0.87*	0.39	54.05**	14.36**	20.22**
Trt x Loc	1	726	-.48[1]	0.03	0.06	0.24	0.07	0.94	0.11	-.32[1]
Res	42	2,963	0.76	0.03	0.04	0.18	0.74	2.72	0.98	2.45
Total	45	3,032	1.58	0.04	0.05	0.19	0.74	4.10	1.24	2.77

[1]Value obtained through subraction resulted in a small negative number due to unequal subclass numbers involved.

*Significant (P<.05)

**Significant (P<.01)

TABLE XV

MEANS FOR CARCASS TRAITS OF 46 STEERS

SLAUGHTERED AT THE SAME TIME

Traits Measured	OSU Meat Laboratory		Commercial Plant	
	Mean	Standard Error	Mean	Standard Error
Number of steers	20		26	
Hot carcass weight	593	10.01	622	11.90
Ribeye area	9.70	0.22	11.50	0.15
Average fat covering	0.92	0.03	0.80	0.03
Single fat covering	0.81	0.05	0.63	0.03
Kidney, heart and pelvic fat, %	3.20	0.09	2.92	0.08
Marbling	4.70	0.16	4.88	0.18
Cutability, %	47.05	0.43	49.24	0.28
Carcass conformation	11.45	0.23	12.58	0.19
Carcass grade	9.30	0.18	9.69	0.26
Carcass length, in.	45.06	0.29	46.39	0.34
Carcass depth, in.	14.63	0.13	14.79	0.14
Armour tenderometer reading	16.15	0.52	17.50	0.64

from handling. It does not seem likely that these differences in preslaughter processing would result in different carcass measurement for these particular traits. Since the two slaughter groups were randomly divided without regard to sire, a highly uneven distribution of offspring within a particular sire could influence the differences obtained. However, the distribution of offspring between the two locations was fairly evenly distributed and should not have contributed to the difference obtained. In fact, in the case of ribeye area larger values were obtained for the steers slaughtered at the commercial packing plant within 9 of the 10 sire groups involved. Also, ribeye area could possibly have been affected by the angle of the cut since different people were involved in making the separations.

Cutability is determined from hot carcass weight, ribeye area, single fat covering and percent kidney, heart and pelvic fat. The fact that all of these factors except hot carcass weight were significantly different probably accounts for cutability being significantly different for the slaughter locations. There are no apparent reasons for significant differences in fat covering and carcass length and therefore can only be explained as a chance occurrence.

Economic Evaluation

An economic evaluation of the feedlot performance for steers on the two treatments involved in this study is presented in Table XVI. Cost per pound of gain was 0.5 of a cent less for the finishing ration. Cost per pound of gain would seem comparably low but this was primarily due to the good feed efficiencies obtained by both groups of cattle. The small difference in cost per pound of gain between the two treatment

TABLE XVI

ECONOMIC EVALUATION OF

FEEDLOT PERFORMANCE

Item	Grower Ration	Finishing Ration
Number of steers	45	46
Feed consumed, lbs.	161,599	151,627
Weight gained, lbs.	24,610	25,285
Cost per pound of gain for:		
Ration costs	$ .143	$ .139
Yardage @ 12¢/head/day	.043	.042
Total cost	$ .186	$ .181

groups along with the similar feedlot performance and carcass data suggests that the actual choice of which ration to feed will be highly dependent upon the relative availability and cost of roughages and concentrates in a particular situation.

CHAPTER V

SUMMARY

A 194 day feeding trial involving 94 Angus steers was conducted at the Fort Reno Livestock Research Station to compare the performance of weaning calves placed directly on a finishing ration with that of steers allowed a growing period before being placed on a high concentrate finishing ration.

The feeding trial was divided into two periods. The first consisted of 76 days where one group was on the grower ration and the other group was on the finishing ration. The second consisted of the remaining 118 days of the trial during which both groups were on the same finishing ration. Total weight, average daily gain, and change in wither height significantly favored the high concentrate group at the end of the first period. Average daily gain during the last period was significantly higher for the steers that had been on the grower ration. However, average daily gain for the entire feeding trial, as well as final weight, was not significantly different. Over the entire feeding trial, the steers on the finishing ration consumed an average of 0.57 pounds less feed per pound of gain than the steers on the grower ration. The economic evaluation showed the cost per pound of gain was 0.5 of a cent less for the finishing ration.

In general the carcass traits were similar for the two treatment groups, however, average fat thickness, carcass grade and marbling score

were significantly higher for the calves on the finishing ration. The correlation between carcass specific gravity with ^{40}K count per pound of live weight and ^{40}K count per pound of hot carcass weight were 0.59 and 0.67, respectively.

A location of slaughter effect was found to be significant ($P<.01$) for ribeye area, single fat covering, cutability, carcass conformation and carcass length. A location effect was also found to be significant ($P<.05$) for average fat covering and percent kidney, heart and pelvic fat. Although not significant, hot carcass weight was heavier for both treatment groups slaughtered at the commercial packing plant.

This study indicated that comparable performance from weaning to slaughter can be obtained on this kind of cattle by either system of management used in this study. The actual choice will be highly dependent upon the relative availability and cost of roughages and concentrates in a particular situation.

LITERATURE CITED

Adams, Nelson J., Z. L. Carpenter, and C. W. Sparth. 1970. Estimation of lamb carcass composition by use of specific gravity measurements. J. Ani. Sci. 31:1081.

Bailey, C. M., C. L. Probert, and V. R. Bohman. 1966. Growth rate, feed utilization and body composition of young bulls and steers. J. Ani. Sci. 25:132.

Black, W. H., J. R. Queensberry, and A. L. Baker. 1940. Wintering steers on different planes of nutrition from weaning to 2 1/2 years of age. U.S.D.A. Tech. Bull. 667.

Bohman, V. R. and Clark Torell. 1956. Compensatory growth of beef cattle: The effect of protein supplements. J. Ani. Sci. 15:1089.

Brackelsberg, P. O. and R. L. Willham. 1968. Relationships among some common live and carcass measurements and beef carcass composition. J. Ani. Sci. 27:53.

Bradley, N. W., L. V. Cundiff, J. D. Kemp, and T. R. Greathouse. 1962. Effects of sex and sire on performance and carcass traits of hereford and hereford-red poll calves. J. Ani. Sci. 21:783.

Carroll, F. D., J. D. Ellsworth, and D. Kroger. 1963. Compensatory carcass growth in steers following protein and energy restriction. J. Ani. Sci. 22:197.

Carroll, F. D., D. D. Nelson, H. Wolf, and G. Plange. 1964. Energy utilization in heifers as affected by a low-protein isocaloric diet. J. Ani. Sci. 23:758.

Cole, J. W., W. R. Backus, and L. E. Orme. 1960. Specific gravity as an objective measure of beef eating quality. J. Ani. Sci. 19:167.

Dahmen, J. J., T. B. Keith, and T. Donald Bell. 1962. Delayed concentrate feeding to steers, Idaho Agr. Exp. Sta. Bull. 374.

DeRámus, H. A., Jr. 1972. Effect of previous plane of nutrition upon the efficiency of energy utilization by beef steers as measured by respiration calorimetry and slaughter. M. S. Thesis, Oklahoma State University, Stillwater, Oklahoma.

Dikeman, M. E., H. J. Tuma, H. A. Glimp, K. E. Gregory and D. M. Allen. 1972. Evaluation of the tenderometer for predicting bovine muscle tenderness. J. Ani. Sci. 34:960.

Dunbar, J. R., D. G. Addis, and G. P. Lofgreen. 1970. Effects of backgrounding cattle for varying periods prior to finishing. Proc. 10th annual California Feeders' Day, p. 18.

Eckles, C. H. and W. W. Swett. 1918. Some factors influencing the rate of growth and the size of dairy heifers at maturity. Mo. Agr. Exp. Sta. Bull. 18.

Forbes, E. B., W. W. Braman, and M. Kriss. 1928. The energy metabolism of cattle in relation to the plane of nutrition. J. Agri. Res. 37:253.

Forbes, E. B., W. W. Braman, and M. Kriss. 1930. Further studies on the energy metabolism of cattle in relation to the plane of nutrition. J. Agr. Res. 40:37.

Fox, D. G. 1970. Physiological factors associated with compensatory growth in beef cattle. Ph.D. dissertation, The Ohio State University.

Fox, D. G., R. R. Johnson, R. L. Preston, T. R. Dockery, and E. W. Klosterman. 1972. Protein and energy utilization during compensatory growth in beef cattle. J. Ani. Sci. 34:310.

Frahm, R. R., L. E. Walters and C. R. McLellan, Jr. 1971. Evaluation of ^{40}K count as a predictor of muscle in yearling beef bulls. J. Ani. Sci. 32:463.

Garrett, W. N. 1971. Energy level, performance, and body composition. Proc. 11th annual California Feeders' Day, p. 24.

Garrett, W. N., J. H. Meyer, and G. P. Lofgreen. 1959. The comparative energy requirements of sheep and cattle for maintainence and gain. J. Ani. Sci. 18:528.

Garrett, W. N., and N. Hinman. 1969. Re-evaluation of the relationship between carcass density and body composition of beef steers. J. Ani. Sci. 28:1.

Graham, N. McC., and T. W. Searle. 1972. Balances of energy in growing sheep at several ages, body weights, and planes of nutrition. Aust. J. Agr. Res. 23:97.

Guenther, J. J., D. H. Bushman, L. S. Pope, and R. D. Morrison. 1965. Growth and development of the major carcass tissues in beef calves from weaning to slaughter weight, with reference to the effect of plane of nutrition. J. Ani. Sci. 24:1184.

Guilbert, H. R., G. H. Hart, K. A. Wagnon, and H. Goss. 1944. The importance of continuous growth in beef cattle. Calif. Agr. Exp. Sta. Bull. 688.

Hammond, J. 1932. Growth and development of mutton qualities in the sheep. Oliver and Boyd, Edinburgh.

Hedrick, H. B. 1968. Bovine growth and composition. Mo. Agri. Exp. Sta. Bull. 928.

Heinemann, W. W., and R. W. VanKeuren. 1956. The effect of wintering plane of nutrition on subsequent gains of beef yearling steers on irrigated pastures. J. Ani. Sci. 15:1097.

Henrickson, R. L. and J. L. Marsden. 1971. Effect of measuring tenderness with the tenderometer. Okla. Agri. Exp. Sta. Mis. Pub. MP-85 p. 73.

Henrickson, R. L., L. S. Pope, and R. F. Hendrickson. 1965. Effect of rate of gain of fattening beef calves on carcass composition. J. Ani. Sci. 24:507.

Hill, F. 1967. The chemical composition of muscles from steers which experienced compensatory growth. J. Sci. Food. Agr. 18:164.

Hogan, A. G. 1929. Retarded growth and mature size of beef steers. Mo. Agr. Exp. Sta. Bull. 123.

Hogan, A. G., W. D. Salmon, and H. D. Fox. 1922. The influence of the plane of nutrition on the maintenance requirements of cattle. Mo. Agr. Exp. Sta. Bull. 51.

Howarth, R. E., and R. L. Baldwin. 1971. Synthesis and accumulation of protein and nucleic acid in rat gastrocnemius muscles during normal growth, restricted growth and recovery from restricted growth. J. Nutr. 101:477.

Joubert, D. M. 1954. The influence of winter nutritional depressions on the growth, reproduction and production of cattle. J. Agr. Sci. 44:5.

Kraybill, H. F., H. L. Bitter, and O. G. Hankins. 1952. Body composition of cattle. II. Determination of fat and water content from measurement of body specific gravity. J. Appl. Physiol. 4:575.

Landers, J. H., Jr., J. D. Wheat, and R. Bogart. 1967. Some factors affecting feed efficiency in beef cattle. Oregon State University Agr. Exp. Sta. Bull. 102.

Lawrence, T. L. S., and J. Pearce. 1964 a, b. Some effects of wintering beef cattle on difficult plans of nutrition. I. Liveweight gain, food consumption and body measurement changes during the winter period and the subsequent grazing period. II. Slaughter data and carcass evaluation. J. Agr. Sci. 63:5, 23.

Levy, D., Y. Folman, Z. Holzer, and D. Drori. 1971. Compensatory growth in intensively raised bull calves. J. Ani. Sci. 33:1078.

Lofgreen, G. P. and W. N. Garrett. 1968. A system for expressing net energy requirements and feed values for growing and finishing beef cattle. J. Ani. Sci. 27:793.

Lush, J., J. M. Jones, W. H. Dameron, and O. L. Carpenter. 1930. Normal growth of range cattle. Texas Agr. Exp. Sta. Bull. 409.

Luizzo, J. A., E. P. Reineke, and A. M. Pearson. 1958. Determination of specific gravity by air displacement. J. Ani. Sci. 17:513.

Maynard, L. A. and J. K. Loosli. 1969. Animal Nutrition. McGraw-Hill Book Co., Inc., New York.

McCay, C. M., M. F. Crowell, and L. A. Maynard. 1935. The effect of retarded growth upon the length of life span and upon ultimate body size. J. Nutr. 10:63.

McMeekan, C. P. 1940. Growth and development in the pig, with special reference to carcass quality characters. I, II, and III. J. Agr. Sci. 30:276, 387, 511.

McMeekan, C. P. 1941. Growth and development in the pig, with special reference to carcass quality characters. IV and V. J. Agr. Sci. 31:1.

Meyer, J. H., J. L. Hull, W. H. Waitkamp, and S. Bonilla. 1965. Compensatory growth responses of fattening steers following various low energy intake regimes on hay or irrigated pasture. J. Ani. Sci. 24:29.

Meyer, J. H., C. E. Lueker, and J. D. Smith. 1956. Influence of food and energy restriction and subsequent recovery on body composition and food utilization of rats. J. Nutr. 60:121.

Meyer, J. H. and A. J. Clawson. 1964. Under nutrition and recovery from under nutrition in rats and sheep. J. Ani. Sci. 23:214.

Meyer, J. H. and W. N. Garrett. 1967. Efficiency of feed utilization. J. Ani. Sci. 26:638.

Moss, F. P. 1968. The relationship between the dimensions of the fibres and the number of nuclei during restricted growth, degrowth, and compensatory growth of skeletal muscle. Am. J. Anat. 122:565.

Murphy, C. E., D. K. Hullett, W. E. Tyler and J. C. Pierce, Jr. 1960. Estimating yields of retail cuts from beef carcasses. J. Ani. Sci. 19:1240.

Naumann, H. D. 1951. A recommended procedure for measuring and grading beef for carcass evaluation. Proc. 4th annual reciprocal meat conference, p. 89.

Nelson, A. B. and W. D. Campbell. 1954. The effect of level of wintering steer calves on their subsequent grazing performance. Okla. Agr. Exp. Sta. Misc. Pub. MP-34.

Oltigen, R. R., T. S. Rumsey, and P. A. Putnam. 1971. All-forage diets for finishing beef cattle. J. Ani. Sci. 32:327.

Osborne, T. B. and L. B. Mendel. 1915a. The resumption of growth after long continued failure to grow. Biol. Chem. 23:439.

Osborne, T. B. and L. B. Mendel. 1915b. The role of gliadin in nutrition. Biol. Chem. 12:473.

Osborne, T. B. and L. B. Mendel. 1916. Acceleration of growth after retardation. Amer. J. Physio. 40:16.

Palsson, H. 1955. Conformation and body composition. Progress in the Physiology of Farm Animals. Edited by J. Hammond. Butterworths Scientific Publications, London.

Palsson, H. and J. B. Verges. 1952. Effects of plane of nutrition on growth and development of carcass quality in lambs. Comparative development of selected individuals of different breeds and crosses as lambs and hoggetts. I and II. J. Agr. Sci. 42:1.

Putnam, P. A., R. Lehmann, and R. E. Davis. 1964. Rate of feed consumption and body weight of beef cattle. J. Ani. Sci. 23:425.

Quinby, F. H. 1948. Food and water economy of the young rat during chronic starvation and recovery. J. Nutr. 36:177.

Richardson, D., E. F. Smith, F. H. Baker, and R. F. Cox. 1961. Effects of roughage-concentrate ratio in cattle fattening rations of gains, feed efficiency, digestion and carcass. J. Ani. Sci. 20:316.

Sheehy, E. J. and B. J. Senior. 1942. Storing cattle at different levels of nutrition. J. Dept. Agr. Eire. 39:245.

Smithson, L., S. A. Ewing, R. E. Renbarger, and L. S. Pope. 1964. Effect of high or low winter feed levels in alternate years on growth and development of beef heifers. Okla. Agr. Exp. Sta. Mis. Pub. MP-74 p. 78.

Snedecor, George W. and W. G. Cochran. 1967. <u>Statistical Methods</u> (6th ed.). Iowa State University Press, Ames, Iowa.

Stearns, G. and D. L. R. Moore. 1931. Growth in height and weight and retention of nitrogen, calcium and phosphorus during recovery from severe malnutrition. Amer. J. Dis. Child. 42:774.

Steel, R. G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., New York.

Stringer, W. C., H. B. Hedrick, C. L. Cramer, R. J. Epley, A. J. Dyer, G. F. Krause, and R. H. White. 1968. Effect of full-feeding for various periods and sire influence on quantitative and qualitative beef carcass characteristics. J. Ani. Sci. 27:1547.

Stuedemann, J. A., J. J. Guenther, S. A. Ewing, R. D. Morrison, and G. V. Odell. 1968. Effect of nutritional level imposed from birth to eight months of age on subsequent growth and development patterns of full-fed beef calves. J. Ani. Sci. 27:234.

Thomas, O. O. 1952. I. Relation of nutrition and age at first calving to lifetime performance of beef cows. II. The effect of low phosphorus rations upon carotene metabolism in ruminants. Ph.D. Thesis, Oklahoma State University, Stillwater, Oklahoma.

Trowbridge, P. F., C. R. Moulton, and L. D. Haigh. 1918. The effect of limited food supply on the growth of young beef animals. Mo. Agr. Exp. Sta. Bull. 28.

Wallace, L. R. 1948. The growth of lambs before and after birth in relation to the level of nutrition. I, II, and III. J. Agr. Sci. 38:93, 243.

Warwick, E. J., R. E. Davis, and R. L. Hiner. 1964. Response of monozygotic bovine twins to high and low concentrate rations. J. Ani. Sci. 23:78 (abstract).

Waters, H. J. 1908. The capacity of animals to grow under adverse conditions. Soc. Prom. Agr. Sci. Proc. 29:71.

Watson, D. M. S. 1943. Beef cattle in peace and war. Emp. J. Exp. Agr. 11:191.

White, T. W., W. L. Reynolds, and R. H. Klett. 1969. Roughage sources and levels in steer rations. J. Ani. Sci. 29:1001.

Wilson, P. N. 1952. Growth analysis of the domestic fowl. I. Age changes in external measurements and carcass composition. J. Agr. Sci. 42:369.

Wilson, P. N. 1954. Growth analysis of the domestic fowl. II. Effect of plane of nutrition on carcass composition. J. Agr. Sci. 44:67.

Wilson, P. N. and D. F. Osbourn. 1960. Compensatory growth after undernutrition in mammals and birds. Biol. Rev. 35:324.

Winchester, C. F. 1951. Influence of interrupted growth of steers on carcass quality and feed economy. J. Ani. Sci. 10:1067 (abstract).

Winchester, C. F. and N. R. Ellis. 1957. Delayed growth of beef cattle. U.S.D.A. Tech. Bull. 1159.

Winchester, C. F. and P. E. Howe. 1955. Relative effects of continuous and interrupted growth on beef steers. U.S.D.A. Agr. Tech. Bull. 1108.

Winchester, C. F., R. L. Hiner, and V. C. Scarborough. 1957. Some effects on beef cattle and protein and energy restriction. J. Ani. Sci. 16:426.

Young, L. G., G. A. Branaman, and R. J. Deans. 1962. Influence of rate of grain feeding on gain and carcass characteristics of calves. J. Ani. Sci. 21:621.

VITA

Lelan Ray Lancaster

Candidate for the Degree of

Master of Science

Thesis: A COMPARISON IN FEEDLOT PERFORMANCE OF STEERS ALLOWED A GROWING PERIOD WITH STEERS PLACED ON A FINISHING RATION AT WEANING

Major Field: Animal Science

Biographical:

Personal Data: Born in Hardtner, Kansas on April 14, 1949, the son of Mr. and Mrs. Arthur Lancaster, Jr.; married Teresa Betty on August 23, 1969; the father of one daughter, Lisa Renee Lancaster.

Education: Graduated from Kiowa High School, Kiowa, Kansas, in May, 1967. Received the Bachelor of Science Degree in Agriculture Education from Oklahoma State University in January, 1971.

Professional Experience: Reared and worked on a general livestock farm in Northwestern Oklahoma; Graduate Assistant at Oklahoma State University, Stillwater, Oklahoma, 1971-72.

Professional Organizations: Alpha Zeta, Phi Kappa Phi, Kappa Delta Pi, and Alpha Tau Alpha.