August 12, 1968

To the Graduate Council:

I am submitting herewith a thesis written by John Albert Allen, Jr. entitled "Effect of Free-Stall Housing on the Performance of Beef Cattle Being Finished for Slaughter." 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.

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EFFECT OF FREE-STALL HOUSING ON THE PERFORMANCE OF BEEF CATTLE BEING FINISHED FOR SLAUGHTER

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements of the Degree

Master of Science

---

by

John Albert Allen, Jr.

August 1968

For their love, understanding, encouragement, and financial support during this endeavor the author dedicates this thesis to his parents, Mr. and Mrs. Albert Allen; his sister, Mary Lee; and his twin brothers, Jimmy and Jerry. To each of them he will always be grateful.

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ABSTRACT

A two-year study, involving 213 steers and heifers, was conducted at the Highland Rim Experiment Station, Springfield, Tennessee.

This study was conducted to (1) compare the performance of cattle finished for slaughter in an open concrete lot with the performance of cattle in a similar lot with access to individual resting stalls, (2) determine the effects of individual resting stalls of different lengths on the performance of cattle of various weights and sexes, and (3) compare the labor requirements for these various feed-lot designs.

The cattle fed in the lots with loafing stalls were significantly cleaner ($P<.05$) than the cattle in open lots. Although there was a positive significant correlation between average daily gain and cleanliness scores in the two periods, only 4.8 percent of the variation in gain was explained during the entire experiment and 10.9 percent during the high-silage phase. Average daily gain for the entire finishing period was 2.11 and 2.14 pounds per head per day for the cattle fed in lots with stalls and those fed in open lots, respectively.

The cattle in lots with stalls were observed resting 14 percent more than those in open lots. However, this additional resting time did not increase gains. The cattle tended to use the free-stalls more during the winter than in the summer.

A maximum of 75 percent of the cattle were observed in the stalls at any time. Therefore, if free-stalls are provided, the maximum need would be about 7 stalls for each 10 animals.

Nine minutes more labor per day or 0.4 hours per head for entire finishing period were required to clean the lots with stalls compared to cleaning the open lots. In addition to the extra labor, there was a bedding cost of $1.00 per animal per trial for the free-stall housed cattle.

The light steers gained faster ($P<.05$) than the heavy steers and heifers; however, condition grades and carcass traits were not significantly different ($P<.05$) among the various types of cattle.

A larger percent of the light steers (68 percent) were observed resting than either the heavy steers (63 percent) or heifers (60 percent).

Feed cost for the light steers was one dollar less per hundred pounds of gain than for either heavy steers or heifers. The light steers and heifers returned $30.00 per head more above feed and initial costs than the heavy steers. This reflects the difference in purchase price. The light steers and heifers were fed with about $1.00 positive margin and the heavy steers were fed at a negative margin.

Animal performance was not significantly affected by the various stall lengths in this study (44, 48, and 52 inches).

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CHAPTER I

INTRODUCTION

Many cattle feeders find that gains decrease and production costs increase during the midwinter feeding period. This reduction in efficiency is often attributed to increased maintenance requirements during periods of low temperature and to mud and manure accumulations. Rain and long periods of cloudy-humid weather often result in extremely soft footing in dirt lots and an accumulation of semi-liquid manure on paved lots. Cleaning of feed lots is generally impractical during periods of adverse winter weather. In addition, facilities for manure disposal are often inadequate during the most favorable conditions and virtually nonexistent during the rainy winter period. When manure is mounded during the summer, portions of the lot may become soft and at times impassable.

Most feed-lots are designed to include a sheltered portion which is bedded frequently to provide a dry area where the cattle may rest. This type of arrangement has two distinct disadvantages: (1) materials and labor for bedding are expensive, and (2) cleaning is more expensive and difficult when bedding material is incorporated in the manure.

The free-stall system has been widely adopted in housing dairy cattle. This system provides a series of separate, bedded stalls wide enough for the animal to lay down and short enough that droppings fall outside of the bedded area. These free-stalls are very similar to the old conventional stall barn except the cattle are "free" to use either

the stalls or the unbedded area. The free-stall housing is designed to allow routine mechanical cleaning, and scraping of the feed-lot area, excluding the bedded stalls. This type of housing has generally resulted in reduced bedding and labor requirements for housing dairy cattle.

Recently, free-stall housing has been considered in beef cattle feed-lot designs. However, there is very little information available regarding the effects of free-stall housing of the performance of beef steers and heifers and the relative housing cost compared to other systems.

The objectives of this study were to: (1) compare the performance of cattle being finished for slaughter in an open concrete lot with the performance of cattle in a similar lot with access to individual resting stalls, (2) determine the effects of individual resting stalls of different lengths on the performance of cattle of various weights and sexes, and (3) compare the labor and bedding requirements for various feed-lot designs.

CHAPTER II

REVIEW OF LITERATURE

I. SHELTER AND SHADE REQUIREMENTS

Shelters are used primarily to protect housed animals from climatic extremes. They accomplish their basic purpose only to the extent that they provide an environment favorable to optimum livestock performance. Although stress can be imposed by such factors as management and nutrition, shelter designs are concerned primarily with climatic environment. Hahn, Thom and Bond (1962) indicated that properly designed shelters and conditioning equipment will reduce environmental stress.

Ittner, Bond and Kelly (1954) concluded that proper precautions in designing and selecting materials for summer feeding facilities materially increased the daily gain of the animals. Measurements of environmental temperatures indicated differences equivalent to 5.5 to 6.0° F. in favor of wire pens compared to heavy wooden corrals. This lower environmental temperature in the wire pens was attributed to three sources, (1) air temperature in the wire pens was usually 1.5 to 2.0° F. lower, (2) air velocity was always greater in the wire pens, and (3) the black globe thermometer readings indicated radiant heat loads as much as 10 BTU less per hour (per square foot of animal surface) which benefited the animals in the wire pens equally as much as lowering the air temperature 4° F.

Shade has been considered necessary to the Southeast to obtain maximum beef cattle performance during the summer. Ensminger (1960)

suggested that an unshaded cow standing in an air temperature of 100° F. has to dispose of enough heat in a 10 hour period to bring 9 gallons of ice water to the boiling point. The Imperial Valley Field Station, El Centro, California, reported that (1) at air temperature of 100° F. the heat load of an animal under a shade 10 to 12 feet high was 1,333 BTU per hour less than that of one in the sun and (2) feed requirements per 100 lb. gain during midsummer was increased 200 to 300 lb. for animals without shade (Bond et al., 1961).

Ittner and Kelly (1951), and Ittner, Bond and Kelly (1954, 1958) stated that good shade will reduce the heat load as much as 50 percent, and will increase gains. An insulating material such as hay or a reflecting material such as aluminum is best for reducing the heat load.

Several studies (Mississippi workers, 1953; Boren et al., 1960; and Totusek, 1953) have shown that proper shade and shelter may significantly increase the performance of beef cattle. However, McCormick, Givens and Southwell (1963) found no significant differences in the gains of steers with and without shade in temperatures up to 92° F. Feed efficiency was improved with the use of shade, but the dressing percent and carcass grade of the steers were not significantly affected.

II. FREE STALLS VERSUS LOOSE HOUSING

The greatest advantage generally attributed to free-stall housing is that it provides each cow with a clean, dry, safe place to lie. However, other management factors such as animal behavior, cow cleanliness, milk production, bedding requirements, and labor and materials handling

should be considered. It is possible that free-stall housing may combine some of the advantages of the stanchion barn and loose housing and eliminate some of the disadvantages of both.

Animal behavior responses. With the introduction of the free-stall system of housing dairy cattle, many studies were conducted to determine its effects on the social behavior of cow herds. Schisseur et al. (1966) reported that group action was the most important single factor in the social behavior of dairy cows in loose housing. Most of the cows in the conventional type housing tended to be more individualistic and group action seldom was evident. In this study, cows in loose housing rested an average of 12 hours and 21 minutes per day compared to 10 hours and 40 minutes for those in free-stalls.

Walker-Love and Laird (1965) found that cows with access to free-stalls chose stalls nearest the door. Their findings agree with observations made by Schmisseur et al. (1966) which indicated that cows preferred stalls that faced other cows. No significant individual stall preference was observed in either of the studies. Crowl and Albright (1965) reported that from 0 to 10 percent of the cows in their studies had to be forced to use stalls.

Additional information regarding the physical, physiological, and psychological activities of the cow as influenced by housing and environment may aid in evaluating the extent of shelter or housing needs.

Cow cleanliness. Cow cleanliness is one of the most important factors in a dairy operation. Properly designed facilities and good

management can result in improved cow cleanliness and milk quality. Results generally indicate that the free-stall housing system provides a means of increasing cow cleanliness and decreasing bedding and labor requirements.

Crowl and Albright (1965) found that subjective ratings indicated cows housed in a free-stall system were cleaner than those in stanchions or loose housing. In a study at Purdue University Dairy Center (Wadsworth, 1964), a filter pad rating system was used to evaluate cow cleanliness. The filter pads were rated 1.9 and 2.5 (on a basis of 1 to 4) for cows housed in free-stalls and loose housing, respectively. Research conducted by Krannert (1965) at the Normandy Farm in Indiana indicated that free-stall cows were cleaner than those in conventional housing.

Schmisseur et al. (1966) reported that when filter pads were collected and scored at weekly intervals to estimate cleanliness, free-stall cows had a cleaner pad in 83 percent of the comparisons. Filter pad scores indicated cows with access to free-stalls bedded with sawdust were cleaner than those using free-stalls bedded with straw.

Data published by Albright, Young and Moeller (1965) indicated that the cows and the bedded area in free-stall housing appeared to be cleaner than in either loose or stanchion housing. Sediment ratings, cow cleanliness scores and condition of the bedded area ratings were 1.6, 2.2, and 2.4; 1.9, 3.4, and 2.6; 1.4, 2.1, and 1.9; for stanchion housing, loose housing, and free-stall housing, respectively. In each rating the lower score indicated greater cleanliness.

Milk production. Schmisseur et al. (1966) reported that the average milk production of the loose housed cows was 50.2 lb. of fat corrected milk (FCM) per cow per day compared to 48.4 lb. per day for the free-stall cows. Free-stall housed cows gained an average of 32 lb. per cow during the experimental period, while loose-housed animals gained 25 lb. These differences in FCM and body weight gain were not significant.

Bedding requirements. A major consideration in studies involving comparisons of loose and free-stall housing has been the relative bedding requirements of the various systems. Bedding of the loafing area tends to prevent injuries, improve cow cleanliness, and absorb excess moisture. However, bedding materials are expensive and often are not readily available.

According to Schmisseur et al. (1966), free-stall systems required 0.25 ton of straw or 0.80 ton of sawdust per cow each 6 month period as compared to one ton of straw or three tons of sawdust for the loose housing system. For each pound of bedding required in the free-stall units at the Purdue Dairy Center, four pounds of bedding were required by the loose housed animals. Loose housed animals required 11 pounds of straw per cow per day while the free-stalled animals required only 2.8 pounds per cow per day (Schmisseur et al., 1966).

Bedding requirement, as determined by Crowl and Albright (1965), was approximately 75 percent less in free-stall housing than in loose housing and 50 percent less than the requirement of stanchion barns.

A study by Wadsworth (1964) during the winter period indicated a

56 to 74 percent reduction in bedding requirements for free-stalls over loose and stanchion housing.

Less bedding was needed (75 percent or more) when free-stall housing was used according to Mentger, Moeller, and Sell (1965).

Labor and materials handling. Since feed and milking time has been excluded from the majority of the dairy data, it appears that the relative labor requirements of the various housing systems may be applied to beef production. Labor requirements and differences reported are for manure handling and bedding of free-stalls or loose housing.

Schmisseur et al. (1966) stated that free-stall animals at the Purdue Dairy Center required an average of 3 hours of labor per cow per winter-spring bedding season compared to only 2.1 hours in loose housing. This savings of approximately one hour (57 minutes) per cow per season was highly significant.

Data reported by Schmisseur et al. (1966a) indicated a labor requirement of 5.3 hours per cow per winter-bedding season in free stalls and 5.1 hours in loose housing. Tractor hours per cow per winter-bedding season amounted to 6.9 hours in free-stall housing compared to only 5.6 hours in conventional loose housing.

Free stalls bedded with straw required the same amount of labor per cow as loose housing bedded with straw. Free stalls bedded with sawdust required 12 minutes more labor per cow than loose housing bedded with sawdust.

Albright, Young and Moeller (1965) found that labor requirements were lower for dairy cattle housed in a free-stall system than for those housed in stanchion barns. The lower requirements in the free-stall system resulted from faster cleanout compared to stanchion barns and less bedding time than tramp sheds. The net advantage of free-stall barns over conventional loose housing amounted to about $13.00 per cow per year. The advantage based on current investment, bedding and labor costs was approximately $22.00 per cow per year for the free-stall system compared to stanchion barns.

Manure was handled with less labor and time in loose housing than in free-stall housing in the study reported by Schmisseur et al. (1966). Total of 4.5 tons of manure was handled per cow in loose housing and 1.4 tons in free stalls. Manure handling required 4.6 hours per cow per season in loose housing and 5.6 hours per cow in free stalls.

It is generally agreed that in a dairy operation the free-stall housing system results in cleaner cows, lower bedding requirements and fewer injuries. However, with modern equipment, materials handling and labor requirements favor loose housing systems.

III. EFFECT OF ENVIRONMENT AND HOUSING ON FEEDLOT PERFORMANCE

Environment, type of housing and feedlot surface appear to have little effect on rate of gain and feed efficiency up to mid-way through the feeding period. However, after this, muddy lots and/or continued exposure to the elements may cause a significant depression in rate and efficiency of gain.

Givens et al. (1967) concluded that the average daily gain of steers having access to stalls was significantly lower ($P<0.01$) than gains made by steers housed in conventional facilities. However, less feed was required per hundred pounds of gain by the steers with access to free stalls. In addition, Nelms and Roubicek (1957) noted that gains made by heifers were affected more severely in the open pens than those made by steers. In this study heifers exhibited more discomfort due to increased temperature than steers.

Morrison, Mendel and Bond (1966) reported that free stalls did not improve weight gains and may have had an adverse effect, especially on steep sloped floors.

According to Geasler and Henderson (1967), there was only a very small difference in the performance of cattle in 10, 40, and 100 percent covered lots; however, considerably less labor was required to manage the 100 percent covered lots. They also reported that data collected in studies at Michigan State University showed no significant difference in the rate and efficiency of gain between cattle in slotted concrete and solid concrete lots.

CHAPTER III

EXPERIMENTAL PROCEDURE

I. SOURCE OF DATA

This study was conducted at the University of Tennessee, Highland Rim Experiment Station, Springfield, Tennessee. Data were collected over the two year period 1965-1967, inclusive. A total of 213 steers and heifers were fed in a pole-type barn constructed to determine the value of free-loafing stalls in a beef cattle finishing operation.

II. EXPERIMENTAL ANIMALS AND FACILITIES

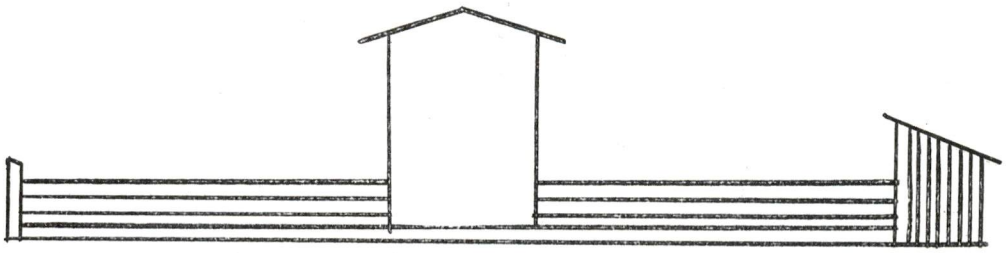
Experimental animals. Most of the animals used in this experiment were purchased by a local order-buyer at the stockyard in Nashville. They represented the general run of stocker-feeder cattle marketed through this facility annually. Their weight varied from 350 to 600 pounds and the grade varied from low-medium to high choice. These cattle were grade Angus, Hereford and various crossbreeds. In addition to the purchased cattle, a limited number of Hereford calves were available each year from the station herd.

After purchase, the animals were transported to the station and any animal showing symptoms of shipping fever was treated with antibiotics. They were grazed in small fescue paddocks near the barns for about a week and observed closely for any sickness. They were fed medium quality hay during this period. After the rest period,

the cattle were weighed, branded, bull calves were castrated, and those with horns were dehorned. They were then grazed on available pasture and fed hay for 30 to 45 days before the experiment was initiated.

Each year the cattle were sorted into three groups (type of cattle). These groups were: (1) heavy steers, (2) light steers, and (3) heifers. Thirty-six heifers, 36 light steers and 36 heavy steers were allotted, within size and sex, to uniform groups of six animals each. Three groups of each type of cattle were randomly assigned to open concrete lots with sheltered resting stalls. The nine groups with access to the individual resting stalls were further randomized within type of cattle to three resting stall depths.

Experimental facilities. A pole-type barn was constructed according to the plan shown in Figure 1. The feed alley and feed bunks were covered by a pole structure which extended about six feet past the feed bunk on each side. A concrete slab 25 feet wide extended the length of the barn on each side of the alley. Each side of the barn was partitioned into nine pens which provided about 100 square feet of open lot area per head. A separate shed was constructed on the north side of the concrete lot to cover the loafing stalls. These stalls consisted of a series of partitioned areas wide enough for the cattle to enter and lie down. They were open at the rear and narrow enough to allow only one animal in a stall at a time. These individual resting stalls had a dirt floor which was covered with a six inch layer of crushed stone and beeded with shavings.



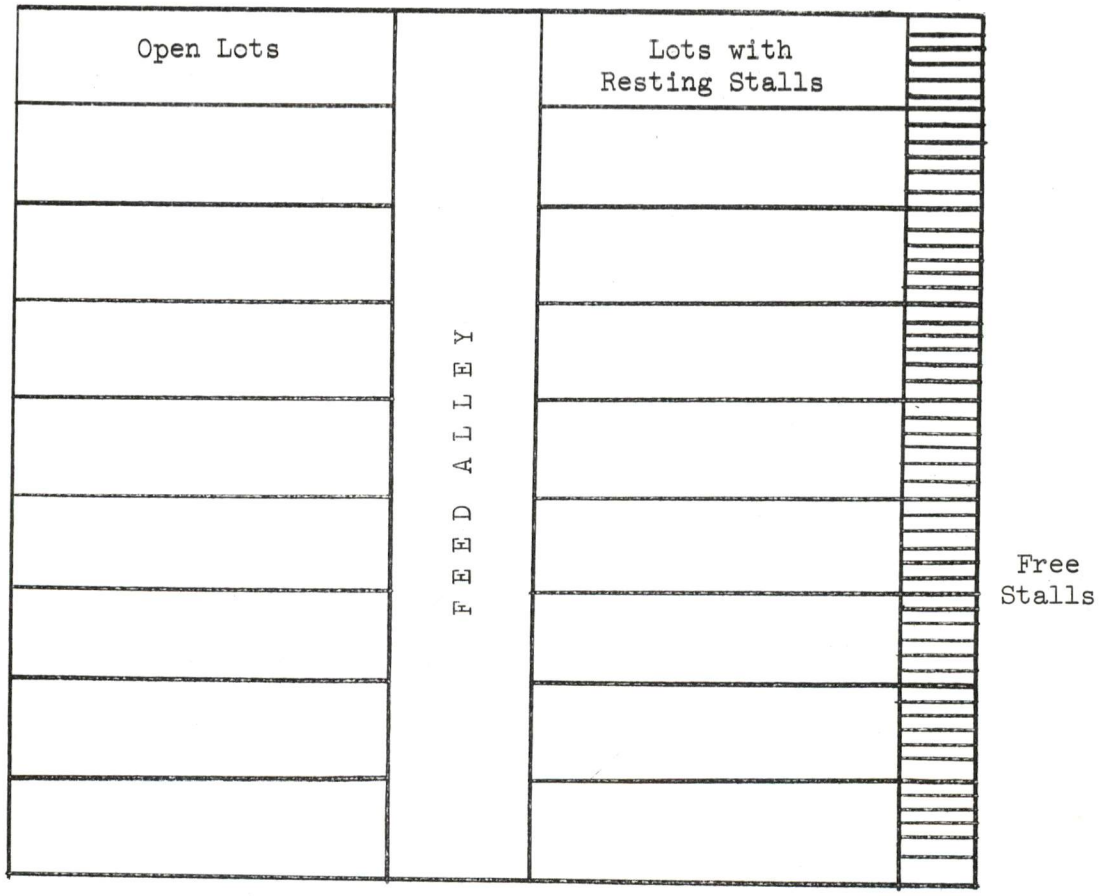


Figure 1. Design of the barn used to compare the two housing systems.

The individual stalls were adjusted to three different lengths. These lengths were 44, 48, and 52 inches. The cattle were "free" to enter and leave the bedded resting stalls as they desired or to rest on the open concrete. The cattle fed in the open lots, on the south side of the alley, did not have any bedded or sheltered area other than that provided by the covered feed bunks. None of the area in the barn except the loafing stalls was bedded.

The fences in the barn were constructed of steel cables to allow maximum air movement through each pen. The barn was designed so that the cattle could be removed and the partition fences opened to allow scraping of one entire side in one operation.

Pens were scraped periodically with a tractor and blade. Any droppings which fell in the resting stalls were removed daily. A detailed labor record was kept to permit evaluation of the efficiency of each design with respect to labor requirement.

Management and records. The first trial was started April 24, 1966, and the second trial started January 6, 1967. The cattle were marketed in July-August. The cattle were weighed, graded, implanted with 24 mg. diethylstilbestrol per head and assigned to their respective lots.

The rations were selected for maximum utilization of high quality corn silage. Initially the cattle were fed corn silage ad lib., one pound of cottonseed meal, about three pounds of alfalfa-grass hay and a limited amount of ground shelled corn per head per day. The

grain ration consisted initially of two pounds per head per day, and was gradually increased to about six pounds by the end of the high-silage phase. Following the high-silage phase the cattle were fed a ground shelled corn-cottonseed meal mixture (7:1) ad lib. and about three pounds of alfalfa-grass hay daily. Water, salt, and a mineral mixture were accessible at all times.

An average of two weights taken on consecutive days were used as the beginning and ending weight for each experimental period. The animals were also weighed at 28-day intervals throughout the experiment. All calves were graded at the beginning and ending of each phase. At the end of the full-feeding phase, the cattle were marketed at a packing plant in the middle Tennessee area where carcass information was obtained.

Each animal was scored bi-weekly, using the following numerical values to indicate relative cleanliness:

1. Clean, no manure on the animal.

2. Fairly clean, some manure on the legs, quarter, or underline.

3. Dirty, manure on the legs, extending forward on the underline and present on both sides.

4. Very dirty, manure caked on legs and underline, extending up sides.

5. Extremely dirty, manure caked on the major portion of the legs, underline and extending up to or near the back.

Daily observations were made of the number of animals resting. In the lots with stalls the number of animals resting on the open

concrete and in the loafing stalls were recorded separately to allow evaluation of the effect of loafing stalls on the resting habits of the various weights and sexes of cattle.

Feeds and cattle prices. The feed prices used to compute feed cost are shown in Table 1. These prices are approximately the cost of each ingredient during the two years of the experiment. The prices of various feed ingredients will vary from year to year or even from day to day. However, feed cost per pound of gain can be computed by multiplying current or applicable price per pound of each ingredient required per pound of gain.

TABLE 1. Feed prices used to compute costs of gain

Ingredient	Price/ton	
	1965-66	1966-67
Shelled corn	$48.20	$48.20
Cottonseed meal	80.00	80.00
Alfalfa-grass hay	35.00	35.00
Silage	8.00	8.00

The initial value per pound for the various types of cattle was based on the average price of the cattle within each type that year.

Statistical analysis. Differences between means for the various performance traits were analyzed by methods outlined by Steele and

concrete and in the loafing stalls were recorded separately to allow evaluation of the effect of loafing stalls on the resting habits of the various weights and sexes of cattle.

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Statistical analysis. Differences between means for the various performance traits were analyzed by methods outlined by Steele and

Torrie (1960) to determine the effects of the independent variables (stalls, type of cattle, and stall length). Analyses were made on a within year basis. It was assumed that the independent variables (stalls vs. no stalls), type of cattle and stall length were fixed and that the individual errors were normally distributed, had an expectation of zero, and the same variance.

The analysis for the primary comparison was based on the following linear additive model:

$$Y_{ijk} = \mu + Y_i + s_j + t_k + (st)_{jk} + e_{ijkl}$$

The secondary comparison was based on the linear model:

$$Y_{ijk} = \mu + y_i + l_j + t_k + e_{ijkl}$$

Where:

Y_{ijk} = the observed value of a given performance trait for the ijkl-th individual

μ = is an effect common to all observations and is the mean of the population

Y_i = is the effect of the i-th year (absorbed)

s_j = is the effect of the j-th barn design

j = 1, lots with loafing barns; 2, open concrete lots

t_k = is the effect of the k-th type of cattle

k = 1, heavy steers; 2, light steers; and 3, heifers

l_j = is the effect of the j-th stall length

j = 1, 44 inches; 2, 48 inches, and 3, 52 inches

$(st)_{jk}$ = is the interaction between barn designs and types of cattle

$(lt)_{jk}$ = is the interaction between stall length and type of cattle

e_{ijkl} = is the random error associated with the ijkl-th individual.

CHAPTER IV

RESULTS AND DISCUSSION

One hundred forty-two steers and seventy-one heifers were fed at the Highland Rim Experiment Station during 1965-1967 to compare the performance of animals in open concrete lots with access to resting stalls (lots with stalls) and animals in open concrete lots without access to resting stalls or any shelter in addition to that provided by the covered feed bunks (open lots).

The cattle were fed silage ad lib. plus limited concentrates and hay (high-silage) for an average of 96 days during the two trials. Following the high-silage period the cattle were full-fed a mixture of ground shelled corn and cottonseed meal (7:1) and about three pounds of hay for an average of 64 days (full-feed). The cattle were fed the high-silage ration for 52 days during the first trial and 141 days during the second trial. The full-feed period varied in length depending on the trial and type of cattle.

I. STALLS AND NO STALLS

Average daily gain. Means of the various traits during the entire finishing period (high-silage and full-feed) for the cattle fed in lots with stalls and in open lots are presented in Table 2. Analysis of variance of mean differences among the various performance and carcass traits are given in Table 3.

The cattle fed in lots with stalls gained 2.11 pounds per head

TABLE 2. Effects of individual resting stalls on the performance of cattle being finished for slaughter

	Open concrete lots with resting stalls	Open concrete lots
No. of animals	107	106
No. of days	160	160
Av. wt. and gain/head, lb.		
Initial wt.	573	577
Final wt.	911	919
Total gain[a]	338	342
Daily gain[a]	2.11	2.14
Av. grades		
Initial type[b]	10.0	9.8
Initial condition	7.8	7.8
Final slaughter[a,b]	11.9	11.9
Carcass, U.S.D.A.[a,b]	12.0	11.9
Financial information, $		
Feed cost/cwt. gain[c]	18.94	18.46
Initial value/cwt.	25.50	25.50
Final value/cwt.	25.25	25.26
Returns/head over feed cost	15.68	16.30
Carcass information		
Hot carcass wt. lb.[a]	552	558
Dressing percent[a]	60.8	61.0

[a]Differences were not statistically significant (P>0.05).

[b]Average choice = 13, Average good = 10.

[c]Feed prices are presented in Table 1.

TABLE 3. Analysis of variance of treatment, stalls versus no stalls, and type of cattle effects on the performance of cattle being finished for slaughter

Source	df	ADG high-silage[a]	ADG full-feed phase[b]	ADG entire experiment[c]	Final slaughter grade	Carcass grade	Dressing percent	Carcass weight	Animal cleanliness
		Mean square							
Stall vs. no stalls	1	3.69**	2.88**	7.82	7.51	11.08	2.10	1,828.29	29.16**
Type of cattle	2	1.24*	1.02*	1.58**	36.96**	37.32**	54.62**	30,669.46**	.19
Stall x type	2	.12	.52	8.64	1.39	.59	2.02	4,243.53	.12
Residual	206	.22	.34	.13	1.73	2.00	4.61	3,208.38	.25

[a]High-silage period is defined on page 19.

[b]Full-feed period is defined on page 19.

[c]Entire experiment is a summation of the high-silage and full-feed periods.

*P<.05.

**P<.01.

per day for the entire finishing period compared to 2.14 pounds per head per day for the cattle fed in open lots. This difference was not statistically significant. However the relationship between gains during the various periods (Table 4) did not follow this pattern. The animals fed in open lots gained 0.16 pounds more ($P<.01$) per head per day during the high-silage period than those fed in lots with stalls. This difference was reversed during the full-feed period when the animals fed in lots with stalls gained 0.20 pounds per head per day more ($P<.05$) than the animals fed in open lots. This reversal rate of gain during the two periods resulted in similar gain over the entire finishing period. These inconsistent differences in rate of gain may be due to restriction of air movement during the winter by the shed which covered the loafing stalls and/or by the inadequacy of shade in the open lots during the summer. In the first trial the high-silage ration was fed from April 24 to July 6 and the full-feed period was from July 6 to August 23. In the second trial the high-silage period extended from January 6 to May 24 and the full-feed phase from May 24 to July 18.

Grades and carcass data. Average slaughter grade, carcass grade, carcass weight, and dressing percent (Table 2) were similar for the cattle fed in lots with stalls and those fed in open lots. Differences between the cattle fed in lots with stalls and in open lots, with respect to these traits, were not statistically significant. This is in agreement with McCormick, Givens and Southwell (1963), who found

TABLE 4. Feed consumption and requirements, stalls versus no stalls

	Lots with stalls		Open lots	
	High-silage ration	Full-feed of concentrates	High-silage ration	Full-feed of concentrates
Number of animals	107	107	107	106
Av. number of days	96	64	96	64
Av. da. feed, lb./hd.				
Shelled corn	7.62	15.74	7.62	16.38
Cottonseed meal	1.36	2.04	1.37	1.97
Alfalfa-grass hay	1.78	1.94	1.86	1.96
Corn silage	24.66		22.98	
Total gain, lb./hd.	193.26	144.45	207.54	132.14
Av. daily gain, lb.[a]	2.07	2.25	2.23	2.06
Feed requirements/cwt. gain, lb.				
Shelled corn	334.75	694.88	305.84	754.00
Cottonseed meal	60.84	89.18	56.04	94.30
Alfalfa-grass hay	84.75	85.86	82.42	94.86
Corn silage	1,152.89		1,039.80	
Feed costs/cwt. gain, $[b]	16.60	21.82	15.06	23.60

[a] 2.07 is significantly different ($P<0.01$) from 2.23 and 2.25 is significantly different ($P<0.01$) from 2.06.

[b] Feed prices are presented in Table 1, page 16.

that shade and shelter did not significantly affect dressing percent or carcass grade.

Animal cleanliness. Average numerical value of biweekly subjective cleanliness scores is presented in Table 5. The cattle in the lots with loafing stalls were significantly cleaner ($P<.05$) than those in open lots. Crowl and Albright (1965), Albright, Young and Moeller (1965) and Schmisseur et al. (1966) reported similar results in which they found that dairy cattle housed in a free-stall system were cleaner than those in stanchions or loose housing.

Correlations between cleanliness score and various other traits are presented in Table 6. Significant positive correlations were found between cleanliness score and average daily gain during the high silage period ($r = 0.33$) and between cleanliness score and average daily gain during the entire experiment ($r = 0.22$). The correlation between cleanliness and average daily gain during full-feed was negative and not significant. Although cleanliness was significantly correlated with gain in the two periods, it only explained 4.8 percent of the variation in gain during the entire experiment and 10.9 percent during the high-silage phases.

These data indicate that animal cleanliness, as measured in this study, does not significantly effect most economically important traits traits of beef animals being finished for slaughter in concrete lots.

Animal resting behavior. An average of 70.2 percent of the cattle being fed in lots with stalls were resting, at the time daily observations

TABLE 5. Relative cleanliness[a] of animals as affected by free-stall housing and type of cattle

Type of cattle	Lots with stalls[b]			Open concrete lots	Overall average by type of cattle disregarding barn design[c]
	Stall length				
	44"	48"	52"		
Heifers	2.28	2.00	1.78	2.71	2.36
Light steers	1.94	1.96	1.84	2.74	2.32
Heavy steers	2.22	2.10	1.92	2.77	2.42
Av. of stall length subclasses[c]	2.14	2.01	1.85		
Stalls vs. no stalls[d]		2.00		2.74	

[a]Relative cleanliness scores were: 1) Clean, no manure on the animal; 2) fairly clean, some manure on legs and underline; 3) dirty, manure on legs, underline, both sides; 4) very dirty, manure caked on legs, underline and up on sides; 5) extremely dirty, manure caked thick on legs and sides extending up to the back.

[b]Free loafing stalls available in addition to an area of uncovered concrete.

[c]Differences between means were not statistically significant ($P>.05$).

[d]Differences between means were statistically significant ($P<.05$).

TABLE 6. Correlation among the various traits evaluated

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Initial weight	1.00	0.29	0.48	0.41	-0.08	0.54	-0.52	0.33	-0.21	-0.25	-0.29	0.42	0.25
2	Initial type		1.00	0.62	-0.22	-0.14	0.28	-0.02	-0.27	0.19	0.05	0.07	0.28	0.11
3	Initial condition			1.00	0.18	-0.17	0.15	-0.36	0.08	-0.01	-0.13	-0.16	0.10	0.17
4	ADG high-silage				1.00	0.00	0.14	-0.30	0.88	-0.28	-0.30	-0.42	0.02	0.33
5	ADG full-feed					1.00	0.34	0.44	0.43	0.18	0.16	-0.00	0.30	-0.15
6	Final weight						1.00	0.44	0.28	0.25	0.20	0.07	0.93	0.10
7	Total gain entire expt.							1.00	-0.07	0.47	0.47	0.38	0.49	-0.17
8	ADG entire expt.								1.00	-0.22	-0.22	-0.40	0.14	0.22
9	Final slaughter grade									1.00	0.66	0.35	0.35	0.01
10	Carcass grade										1.00	0.44	0.33	-0.04
11	Dressing percent											1.00	0.38	-0.15
12	Carcass weight												1.00	0.06
13	Cleanliness score													1.00

Correlation coefficients $\geq$ 0.195 are significant ($P<.05$).

Correlation coefficients $\geq$ 0.254 are highly significant ($P<.01$).

were made, compared to only 58.0 percent of those being fed in the open lots (Table 7). However, this additional time spent resting by the cattle in the lots with stalls did not affect their performance when compared to that of the cattle which rested less frequently in the open lots.

At the time of the daily observations the cattle in the lots with stalls were found resting in the bedded stalls and on the open concrete about an equal amount of the time. It was observed that ambient temperature, precipitation, and cleanliness of the concrete slab tended to influence the ratio of cattle resting in the loafing stalls to those resting on the concrete slab in the lots where the cattle were free to choose between the two areas. The cattle tended to use the free-stalls more during the winter than they did in the summer. No more than 70 percent of the cattle in any lots was observed resting in stalls at any one time. This supports the statement by Givens et al. (1967) that if loafing stalls are provided, it is necessary to calculate only 75 percent use at any time.

Feed requirements, consumption and cost. The cattle in the lots with stalls consumed about two pounds more silage per head per day than those fed in open lots when fed the high-silage ration (Table 4, p. 23). However, they required about one pound more silage per pound of gain than the cattle in open lots. Feed cost per unit of gain was higher for the cattle fed in lots with stalls during this high-silage phase.

During the full-feed phase the cattle fed in open lots consumed 0.8 pounds more concentrates per head per day than those fed in lots

TABLE 7. Effects of loafing stalls and type of cattle on the resting behavior of feeder cattle

	Percent resting[a]				
	Concrete lots with loafing stalls			Open concrete lots with no stalls	Average by type of cattle
	In stalls	On concrete	Total		
Heifers	30.5	35.0	65.5	59.5	60
Light steers	33.5	41.5	75.0	59.5	68
Heavy steers	31.0	38.0	70.0	55.0	63
Average	31.7	38.2	70.2	58.0	

[a]Based on daily observations made at random times between 6:00 a.m. and 8:30 p.m.

with stalls. Feed requirement and feed cost per unit of gain were higher for the cattle fed in open lots during this phase.

When considered over the entire finishing period, feed cost per pound of gain was similar for the two types of feed lots. These costs were $20.58 and $19.46 for the cattle fed in lots with stalls and open lots, respectively.

Labor and materials handling. Nine minutes more labor was required per day to clean the lots with stalls than was required to clean the open lots (Table 8). When labor requirement was considered on a per head basis, 0.4 hour more labor per head was required to clean the lots with stalls during the 160 day finishing period. These results are similar to those reported by Schmisseur et al. (1966), who found free-stall cattle required 0.9 hours more labor per head per winter than the loose housed animals, but is contradictory to the work of Albright, Young and Moeller (1965), who reported that labor requirements were lower for cattle in a free-stall system. However, Albright, Young and Moeller (1965) reported labor requirements for bedding the loose housing area and no bedding was used in the open lots of this study.

In addition to the labor that was required to bed the free stalls, there was a small cost for bedding materials. In this study wood shavings were used as bedding and the cost for the 54 cattle in lots with free stalls was about $1.00 per animal for each trial.

TABLE 8. Time required to clean manure from loafing stalls and to scrape concrete lots

	Lots with stalls			Open lots
	Scraping concrete lots	Cleaning stalls	Total	Scraping concrete lots
	Min. per day			
First trial	9.2	8.5	17.7	9.1
Second trial	7.3	9.3	16.6	7.3
Average	8.2	8.9	17.1	8.2

II. TYPE OF CATTLE

The three types of cattle used in this study were: (1) heavy steers, (2) light steers, and (3) heifers. The average performance of the various types of cattle is presented in Table 9. Analysis of variance of these performance traits is given in Table 3, page 21. Performance during the various trials is shown in Appendix Tables 23 and 24.

Average daily gain. Both the heavy and light steers gained significantly faster ($P<.05$) than the heifers during the high-silage period and the entire finishing period. However, the heifers gained about 0.2 pound per head per day more than the steers during the full-feed period. The heavy steers, light steers and heifers gained 2.13, 2.21 and 1.75 pounds per head per day, respectively, during the entire finishing period. Daily gains during the high-silage and full-feed periods were 2.13, 2.17, and 2.00; and 2.19, 2.24, and 2.34 pounds per head for the three types of cattle, respectively (Table 10).

The performance of the three types of cattle when fed in lots with stalls and in open lots is shown in Table 11. The free-stall housing did not significantly affect the performance of the various types of cattle. Gains of the cattle fed in lots with stalls and in open lots were 2.16 and 2.25; 2.18 and 2.09; and 1.99 and 2.05 pounds per head per day for light steers, heavy steers and heifers, respectively.

Slaughter grades and carcass data. Carcass data for the three types of cattle is presented in Table 9. Average slaughter and carcass

TABLE 9. Performance of various sexes and weights of cattle being finished for slaughter

	Light steers	Heavy steers	Heifers
No. of animals	70	72	71
No. of days	182	141	182
Av. wt. and gain/head, lb.			
Initial wt.	515	655	552
Final wt.	917	956	871
Total gain	402	301	319
Daily gain	2.21	2.13	1.75
Av. grades			
Initial type[a]	9.4	10.6	9.6
Initial condition[a]	7.4	8.2	7.6
Final slaughter	12.3[b]	11.1[a,c]	12.5[b]
Carcass, U.S.D.A.	12.6[b]	11.1[a,c]	12.0[b]
Financial information, $			
Feed cost/cwt. gain[d]	18.16	18.53	19.46
Initial value/cwt.	25.50	27.50	23.50
Final value/cwt.	26.16	24.80	24.84
Returns/hd. over feed cost	29.82	-1.85	29.82
Carcass information			
Hot carcass wt., lb.	562	570	531
Dressing percent	61.6[a,c]	59.7[b]	61.3[a,c]

[a]Average choice = 13, average good = 10.

[b,c]Means in this line not superscripted with same letter are significantly different ($P<.05$).

[d]Feed prices are presented in Table 1.

TABLE 10. Feed consumption and requirements, type of cattle

	High-silage[a]			Full-feed[a]		
	Heavy steers	Light steers	Heifers	Heavy steers	Light steers	Heifers
Number of animals	36	35	36	36	35	36
Number of days	96	96	96	44	86	54
Av. da. feed, lb./hd.						
Shelled corn	8.12	7.31	7.32	15.94	15.80	15.40
Cottonseed meal	1.41	1.30	1.31	2.05	1.98	1.96
Alfalfa-grass hay	1.78	1.84	1.79	2.02	1.92	1.98
Corn silage	22.80	18.52	23.06	---	---	---
Total feed consumed, lb./hd.						
Shelled corn	663.62	622.38	623.80	701.86	1,337.52	951.06
Cottonseed meal	123.66	117.00	117.32	90.18	168.76	120.65
Alfalfa-grass hay	178.53	182.46	180.90	90.00	166.25	121.00
Corn silage (as fed)	2,528.52	2,156.25	2,242.82	---	---	---
Total gain, lb./hd.	204.92	207.93	192.12	96.54	192.85	126.62
Av. daily gain, lb.	2.13[b]	2.17[b]	2.00[c]	2.19	2.24	2.34
Feed requirements/cwt. gn., lb.						
Shelled corn	325.34	298.96	329.92	758.64	691.89	747.36
Cottonseed meal	59.33	54.68	59.99	96.66	87.18	94.92
Alfalfa-grass hay	81.14	81.58	86.74	95.42	85.30	95.92
Corn silage	889.52	720.68	1,099.21	---	---	---
Feed costs/cwt. gain, $	16.33	15.24	16.26	23.82	21.66	23.48

[a]High-silage and full-feed are explained on page 19.

[b]Heavy steers and light steers gain significantly ($P<.05$) faster than the heifers.

[c]Light steers gain significantly ($P<.05$) faster than the heavy steers and heifers.

TABLE 11. The effects of individual resting stalls on the performance of various sexes and weights of cattle being finished for slaughter

	Light steers		Heavy steers		Heifers	
	Resting stalls	Open concrete	Resting stalls	Open concrete	Resting stalls	Open concrete
Number of animals	35	35	36	36	36	35
Number of days	182	182	141	141	158	158
Av. wt. and gain/head, lb.						
Initial wt.	512	519	654	656	550	554
Final wt.	906	928	962	951	864	878
Total gain	394	409	308	295	314	324
Daily gain	2.16	2.25	2.18	2.09	1.99	2.05
Av. grades						
Initial type	9.4	9.3	10.5	10.6	9.6	9.6
Initial condition	7.4	7.4	8.2	8.2	7.6	7.7
Final slaughter	12.2	12.4	11.2	11.0	12.4	12.2
Carcass, U.S.D.A.	12.7	12.5	11.0	11.2	12.0	12.0
Financial information, $						
Feed cost/cwt. gain	18.48	17.82	18.46	18.60	19.82	19.11
Initial value/cwt.	25.50	25.50	27.50	27.50	23.50	23.50
Final value, cwt.	26.01	26.21	24.92	24.74	24.91	24.78
Returns/hd. over feed cost	26.69	32.96	3.82	-6.90	17.15	18.76
Carcass information						
Hot carcass wt., lb.	554	571	576	565	526	537
Dressing percent	61.2	62.0	59.9	59.5	61.1	61.4

grades of the light steers and heifers were significantly greater ($P<.05$) than those of the heavy steers. Numerical values of the live slaughter and carcass grades were: light steers, 12.3 and 12.6; heavy steers, 11.1 and 11.1; and heifers, 12.5 and 12.0. The average dressing percent was higher ($P<.05$) for the light steers and heifers than for the heavy steers. The average dressing percents were 61.6, 61.3 and 59.7, respectively, for the three groups.

The carcasses of the heavy steers were 8 pounds heavier than the carcasses of the light steers and 39 pounds heavier than those of the heifers. These differences in carcass weight reflect the differences in final weight of the various types of cattle.

Within each type of cattle, the various carcass characteristics were not affected by the availability of free loafing stalls in the feed lots (Table 11).

Animal cleanliness. The average cleanliness scores for the heavy steers, light steers, and heifers were 2.42, 2.32, and 2.36. These differences in cleanliness were not statistically significant ($P>.05$). The difference in cleanliness of the three types of cattle was of the same rank with respect to those fed in lots with stalls or in open lots.

Animal resting behavior. A larger percent of the light steers were resting at the time of daily observations than either the heavy steers or heifers. This was true for both the cattle fed in the lots with stalls and those fed in open lots. The average percent of the cattle resting was 63, 68 and 60 percent for heavy steers, light steers, and heifers, respectively (Table 7, p. 28).

Feed requirement and costs. Average feed requirements for the various types of cattle are presented in Table 10, page 33. During the high-silage phase the heavy steers and heifers consumed about 4.5 pounds more silage per head per day than the light steers. However, there were no differences in the daily feed consumption of the various groups during full-feed.

In both the high-silage and the full-feed period, the feed requirement per pound of gain was less for the light steers than the heavy steers or heifers. This was reflected in feed cost per pound of gain (Table 10). The cost per pound of gain was 16.3, 15.2 and 16.3 cents for the heavy steers, light steers and heifers, respectively, during the high silage phase. The cost per pound of gain was 18.5, 18.2 and 19.5 cents for the three groups, respectively, for the entire experiment.

Return above feed and initial costs was about $30.00 per head more from the light steers and heifers than from the heavy steers. This difference reflects the difference in purchase price. The light steers and heifers were fed with about $1.00 positive margin between purchase and selling price per hundred pounds. However, the heavy steers were fed at a negative margin.

III. STALL LENGTH

The secondary consideration in this trial was the comparison of the effects of varying stall lengths on the performance of the various types of cattle. The stalls compared were 44, 48, and 52 inches from

front to rear. The average performance of the cattle fed in the lots with the three different stall lengths are presented in Table 12. The analysis of variance of the effects of stall length on the various performance traits are presented in Table 13.

Aminal gain, slaughter grade, carcass grade, dressing percent, carcass weight, and animal cleanliness were not significantly different ($P<.05$) between the cattle fed in the lots with stalls 44, 48, and 52 inches deep. There was no significant interaction between stall length and type of cattle, each of the various types of cattle performed silimar regardless of stall length.

The average percentage of cattle resting and the location of these cattle at the time of daily observations is presented in Table 14. These percentages were 69, 71, and 69 for the cattle fed in lots with stalls 44, 48, and 52 inches in length, respectively.

When the effects of varying stall length was considered on the basis of the three types of cattle, no significant trend with respect to preference to a given stall length was observed. Regardless of stall length or type of cattle, about 50 percent of the cattle observed resting were in the stalls and about 50 percent were on the open concrete slab.

TABLE 12. The effects of resting stalls of varying lengths on the performance of cattle being finished for slaughter

	44" resting stalls	48" resting stalls	52" resting stalls
No. of animals	36	36	35
Av. no. of days	160	160	160
Av. wt. and gain/head, lb.			
Initial wt.	568	578	574
Final wt.	907	905	927
Total gain	339	329	348
Daily gain	2.12	2.06	2.18
Av. grades			
Initial type	9.8	9.8	10.2
Initial condition	7.6	7.8	7.9
Final slaughter	12.0	11.8	12.0
Carcass, U.S.D.A.	12.2	11.9	11.8
Carcass information			
Hot carcass wt., lb.	548	552	556
Dressing percent	60.7	61.0	60.6

TABLE 13. Analysis of variance of stall length and type of cattle effects on the performance of cattle being finished for slaughter

Source	df	ADG high-silage[a]	ADG full-feed phase[b]	ADG entire experiment	Final slaughter grade	Carcass grade	Dressing percent	Carcass weight	Animal cleanliness
		Mean square							
Stall length	2	.61	.26	.24	.45	1.16	1.61	769.44	7,755.76
Type of cattle	2	.72	.60	.95**	16.46**	23.47**	18.43	23,803.38**	2,714.51
Length of stall x type	2	.20	.52	.16	.53	.89	7.12	1,831.12	1,294.41
Residual	97	.23	.27	.12	1.69	1.93	5.11	3,017.14	2,927.46

[a]High-silage period is defined on page 19.

[b]Full-feed period is defined on page 19.

*P<.05.

**P<.01.

TABLE 14. Effects of loafing stall length on the resting behavior of three types of feeder cattle

	Percent resting[a]		
	In stalls	On concrete	Total
44" stalls			
Heifers	29.50	33.50	63.00
Light steers	35.00	41.00	76.00
Heavy steers	33.50	35.50	69.00
Average	32.50	36.50	69.00
48" stalls			
Heifers	36.00	30.00	66.00
Light steers	35.00	42.50	77.50
Heavy steers	28.00	42.00	70.00
Average	33.00	38.00	71.00
52" stalls			
Heifers	33.00	33.00	66.00
Light steers	31.00	41.00	72.00
Heavy steers	32.00	37.00	69.00
Average	32.00	37.00	69.00

[a]Based on daily observations made at random times between 6:00 a.m. and 8:30 p.m.

CHAPTER V

SUMMARY

A two-year study, involving 213 heifers and steers, was conducted at the Highland Rim Experiment Station, Springfield, Tennessee.

This study was conducted to: (1) compare the performance of cattle finished for slaughter in an open concrete lot with the performance of cattle in a similar lot with access to individual resting stalls, (2) determine the effects of individual resting stalls of different lengths on the performance of cattle of various weights and sexes, and (3) compare the labor requirements for these various feed-lot designs.

The cattle fed in the lots with loafing stalls were significantly cleaner ($P<.05$) than the cattle in open lots. Although there was a positive significant correlation between average daily gain and cleanliness scores in the two periods, only 4.8 percent of the variation in gain was explained during the entire experiment and 10.9 percent during the high-silage phase. Average daily gain for the entire finishing period was 2.11 and 2.14 pounds per head per day for the cattle fed in lots with stalls and those fed in open lots, respectively.

The cattle in lots with stalls were observed resting 14 percent more than those in open lots. However, this additional resting time did not increase gains. The cattle tended to use the free-stalls more during the winter than in the summer.

A maximum of 75 percent of the cattle were observed in the stalls at any time. Therefore, if free-stalls are provided, the maximum need

would be about 7 stalls for each 10 animals.

Nine minutes more labor per day or 0.4 hours per head for entire finishing period were required to clean the lots with stalls compared to cleaning the open lots. In addition to the extra labor, there was a bedding cost of $1.00 per animal per trail for the free-stall housed cattle.

The light steers gained faster ($P<.05$) than the heavy steers and heifers; however, condition grades and carcass traits were not significantly different ($P<.05$) among the various types of cattle.

A larger percent of the light steers (68 percent) were observed resting than either the heavy steers (63 percent) or heifers (60 percent).

Feed cost for the light steers was $1.00 less per hundred pounds of gain than for either heavy steers or heifers. The light steers and heifers returned $30.00 per head more above feed and initial costs than the heavy steers. This reflects the difference in purchase price. The light steers and heifers were fed with about $1.00 positive margin and the heavy steers were fed at a negative margin.

Animal performance was not significantly affected by the various stall lengths in this study (44, 48, and 52 inches).

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LITERATURE CITED

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APPENDIX

TABLE 15. Effects of individual resting stalls on the performance of cattle being finished for slaughter (Trial 1)

	Open concrete lots with resting stalls	Open concrete lots
No. of animals	53	54
No. of days	109	109
Av. wt. and gain/head, lb.		
Initial wt.	619	617
Final wt.	893	901
Total gain	273	284
Daily gain	2.50	2.60
Av. grades		
Initial type	9.6	9.5
Initial condition	8.1	8.1
Final slaughter	11.4	11.5
Carcass, U.S.D.A.	11.5	11.3
Financial information, $		
Feed cost/cwt. gain	18.75	17.98
Initial value/cwt.	25.50	25.50
Final value/cwt.	24.14	24.32
Returns/head over feed cost	6.89	7.82
Carcass information		
Hot carcass wt., lb.	533	541
Dressing percent	59.3	60.3

TABLE 16. Effects of individual resting stalls on the performance of cattle being finished for slaughter (Trial 2)

	Open concrete lots with resting stalls	Open concrete lots
No. of animals	54	52
No. of days	212	212
Av. wt. and gain/head, lb.		
Initial wt.	527	537
Final wt.	929	937
Total gain	402	400
Daily gain	1.90	1.89
Av. grades		
Initial type	10.4	10.2
Initial condition	7.5	7.5
Final slaughter	12.4	12.3
Carcass, U.S.D.A.	12.4	12.5
Financial information, $		
Feed cost/cwt. gain	19.12	18.94
Initial value/cwt.	25.50	25.50
Final value, cwt.	26.36	26.20
Returns/head over feed cost	24.48	24.77
Carcass information		
Hot carcass wt., lb.	571	575
Dressing percent	62.2	61.7

TABLE 17. Feed consumption and requirements (Trial 1)

	Lots with stalls		Open lots	
	High-silage ration	Full-feed of concentrates	High-silage ration	Full feed of concentrates
Number of animals	53	53	54	54
Number of days	52	57	52	57
Av. da. feed. lb./hd.				
Shelled corn	9.8	16.5	9.7	18.1
Cottonseed meal	1.6	2.1	1.6	2.1
Alfalfa-grass hay	1.6	1.9	1.7	2.1
Corn silage	25.5		24.2	
Total gain, lb./hd.	143.2	130.2	168.0	116.4
Av. daily gain, lb.	2.75	2.31	3.23	2.05
Feed requirement/cwt. gain, lb.				
Shelled corn	354.6	716.6	301.5	803.2
Cottonseed meal	57.1	89.5	48.5	100.2
Alfalfa-grass hay	56.4	82.7	51.6	93.8
Corn silage	924.6		749.2	
Feed costs/cwt. gain, $	15.51	22.31	13.11	25.00

TABLE 18. Feed consumption and requirements (Trial 2)

	Lots with stalls		Open lots	
	High-silage ration	Full-feed of concentrates	High-silage ration	Full-feed of concentrate
Number of animals	54	54	53	52
Number of days	141	71	141	71
Av. da. feed, lb./hd.				
Shelled corn	5.43	14.98	5.54	14.67
Cottonseed meal	1.11	1.98	1.14	1.84
Alfalfa-grass hay	1.95	1.98	2.02	2.01
Corn silage	23.83		23.76	
Total gain, lb./hd.	243.31	158.70	247.08	147.87
Av. daily gain, lb.	1.73	2.22	1.79	2.08
Feed requirements/cwt. gain, lb.				
Shelled corn	314.90	673.16	310.19	704.81
Cottonseed meal	64.59	88.87	63.58	88.41
Alfalfa-grass hay	113.10	89.01	113.24	96.63
Corn silage	1,381.18		1,330.39	
Feed costs/cwt. gain, $	17.68	21.34	17.02	22.21

TABLE 19. Relative cleanliness[a] of animals as affected by free-stall housing and type of cattle (Trial 1)

Type of cattle	Lots with stalls[b] Stall length 44"	48"	52"	Open concrete lots	Overall average by type of cattle disregarding barn design[c]
Heifers	2.61	2.64	2.17	2.82	2.65
Light steers	1.97	2.44	2.06	2.74	2.45
Heavy steers	2.83	1.79	2.25	2.83	2.56
Av. of stall length subclasses[c]	2.47	2.29	2.16		
Stalls vs. no stalls[d]		2.31		2.80	

[a]Relative cleanliness scores are shown in Table 5, page 25.

[b]Free loafing stalls available in addition to an area of uncovered concrete.

[c]Differences between means were not statistically significant ($P>.05$).

[d]Differences between means were statistically significant ($P<.05$).

TABLE 20. Relative cleanliness[a] of animals as affected by free-stall housing and type of cattle (Trial 2)

Type of cattle	Lots with stalls[b]			Open concrete lots	Overall average by type of cattle disregarding barn design[c]
	Stall length				
	44"	48"	52"		
Heifers	1.94	1.37	1.40	2.60	2.07
Light steers	1.90	1.48	1.63	2.75	2.20
Heavy steers	1.62	2.40	1.58	2.71	2.29
Av. of stall length subclasses[c]	1.82	1.73	1.54		
Stalls vs. no stalls[d]		1.70		2.69	

[a]Relative cleanliness scores are shown in Table 5, page 25.

[b]Free loafing stalls available in addition to an area of uncovered concrete.

[c]Differences between means were not statistically significant (P>.05).

[d]Differences between means were statistically significant (P<.05).

TABLE 21. Effects of loafing stalls and type of cattle on the resting behavior of three types of feeder cattle (Trial 1)

	Percent resting[a]				
	Concrete lots with loafing stalls			Open concrete lots with no stalls	Average by type of cattle
	In stalls	On concrete	Total		
Heifers	18	47	65	54	59
Light steers	12	59	71	55	63
Heavy steers	15	56	71	56	64
Average	15	54	69	55	

[a]Based on daily observations made at random times between 6:00 a.m. and 8:30 p.m.

TABLE 22. Effects of loafing stalls and type of cattle on the resting behavior of three types of feeder cattle (Trial 2)

	Percent resting[a]				
	Concrete lots with loafing stalls			Open Concrete lots with no stalls	Average by type of cattle
	In stalls	On concrete	Total		
Heifers	43	23	66	55	62
Light steers	55	24	79	64	72
Heavy steers	47	20	69	54	62
Average	48	22	72	58	

[a]Based on daily observations made at random times between 6:00 a.m. and 8:30 p.m.

TABLE 23. Feed consumption and requirements (Trial 1)

	High-silage			Full-feed		
	Heavy steers	Light steers	Heifers	Heavy steers	Light steers	Heifers
Number of animals	36	35	36	36	35	36
Number of days	52	52	52	34	68	52
Av. da. feed, lb./hd.						
Shelled corn	10.8	9.2	9.2	16.6	17.0	16.0
Cottonseed meal	1.7	1.5	1.5	2.1	2.1	2.0
Alfalfa-grass hay	1.6	1.7	1.6	2.0	1.9	1.9
Corn silage	27.0	24.7	22.7	---	---	---
Total feed consumed, lb./hd.						
Shelled corn	559.8	480.1	480.8	564.1	1,155.7	1,088.4
Cottonseed meal	90.1	77.1	77.4	70.3	144.3	135.9
Alfalfa-grass hay	80.7	87.4	83.2	67.2	132.1	128.2
Corn silage	1,404.5	1,286.1	1,182.1	---	---	---
Total gain, lb./hd.	167.8	161.4	138.1	65.8	170.7	134.6
Av. daily gain, lb.	3.23	3.10	2.65	1.93	2.51	1.98
Feed requirements/cwt. gn., lb.						
Shelled corn	33.6	297.4	348.3	857.6	677.1	808.8
Cottonseed meal	53.7	47.7	56.1	106.8	84.5	101.0
Alfalfa-grass hay	48.1	54.1	60.3	102.2	77.4	95.3
Corn silage	790.0	796.7	856.3	---	---	---
Feed costs/cwt. gain, $	14.38	13.21	15.12	26.73	21.05	25.20

TABLE 24. Feed consumption and requirements (Trial 2)

	High-silage			Full-feed		
	Heavy steers	Light steers	Heifers	Heavy steers	Light steers	Heifers
Number of animals	36	35	35	36	35	35
Number of days	141	141	141	55	104	55
Av. da. feed, lb./hd.						
Shelled corn	5.44	5.42	5.44	15.27	14.61	14.79
Cottonseed meal	1.12	1.11	1.12	2.00	1.86	1.92
Alfalfa-grass hay	1.96	1.97	1.98	2.05	1.93	2.07
Corn silage	18.64	12.35	23.43	---	---	---
Total feed consumed, lb./hd.						
Shelled corn	767.44	764.66	766.80	839.61	1,519.34	813.71
Cottonseed meal	157.22	156.91	157.23	110.06	193.23	105.40
Alfalfa-grass hay	276.36	277.51	278.60	112.81	200.40	113.80
Corn silage	3,652.53	3,026.40	3,303.54	---	---	---
Total gain, lb./hd.	242.03	254.46	246.14	127.28	215.00	118.63
Av. daily gain, lb.	1.72	1.80	1.75	2.31	2.07	2.16
Feed requirements/cwt. gn., lb.						
Shelled corn	317.09	300.51	311.53	659.67	706.68	685.93
Cottonseed meal	64.96	61.67	63.88	86.47	89.87	88.85
Alfalfa-grass hay	114.19	109.06	113.19	88.63	93.21	95.93
Corn silage	989.03	644.66	1,342.12	---	---	---
Feed costs/cwt. gain, $	18.28	17.27	17.41	20.91	22.26	21.76

TABLE 25. The effects of individual resting stalls on the performance of various sexes and weights of cattle being finished for slaughter (Trial 1)

	Light steers		Heavy steers		Heifers	
	Resting stalls	Open concrete	Resting stalls	Open concrete	Resting stalls	Open concrete
Number of animals	17	18	18	18	18	18
Number of days	120	120	86	86	120	120
Av. wt. and gain/head, lb.						
Initial wt.	561	562	701	700	592	589
Final wt.	889	898	931	937	858	869
Total gain	328	336	230	237	266	280
Daily gain	2.73	2.80	2.67	2.76	2.21	2.33
Av. grades						
Initial type	8.6	8.7	9.9	10.3	9.5	9.5
Initial condition	7.3	7.4	8.5	8.6	7.9	8.3
Final slaughter	11.6	11.8	10.0	10.0	12.6	12.6
Carcass, U.S.D.A.	12.3	11.8	9.9	10.0	12.2	12.2
Financial information, $						
Feed cost/cwt. gain	17.30	17.18	18.26	17.47	20.76	19.46
Initial value/cwt.	25.50	25.50	27.50	27.50	23.50	23.50
Final value/cwt.	25.03	25.28	23.56	23.57	24.02	24.01
Returns/hd. over feed cost	20.96	23.87	-5.30	-18.35	6.22	9.78
Carcass information						
Hot carcass wt., lb.	537	547	549	546	512	529
Dressing percent	60.0	61.6	58.2	58.0	59.7	61.1

TABLE 26. The effects of individual resting stalls on the performance of various steers and weights of cattle being finished for slaughter (Trial 2)

	Light steers		Heavy steers		Heifers	
	Resting stalls	Open concrete	Resting stalls	Open concrete	Resting stalls	Open concrete
Number of animals	18	17	18	18	18	17
Number of days	245	245	196	196	196	196
Av. wt. and gain/head, lb.						
Initial wt.	464	476	608	612	508	518
Final wt.	923	958	994	965	870	886
Total gain	459	482	386	353	362	368
Daily gain	1.87	1.97	1.97	1.80	1.85	1.87
Av. grades						
Initial type	10.2	9.9	11.1	11.0	9.8	9.8
Initial condition	7.4	7.3	7.9	7.9	7.3	7.1
Final slaughter	12.8	13.1	12.3	12.0	12.3	11.8
Carcass, U.S.D.A.	13.1	13.2	12.2	12.5	11.9	11.9
Financial information, $						
Feed cost/cwt. gain	19.67	18.46	18.67	19.74	18.89	18.76
Initial value/cwt.	25.50	25.50	27.50	27.50	23.50	23.50
Final value/cwt.	27.00	27.14	26.27	25.92	25.80	25.55
Returns/hd. over feed cost	32.42	42.04	12.94	4.54	28.08	27.73
Carcass information						
Hot carcass wt., lb.	570	595	604	584	539	545
Dressing percent	62.5	62.6	61.6	61.0	62.5	61.7

TABLE 27. Effects of loafing stall length on the resting behavior of three types of feeder cattle (Trial 1)

	Percent resting[a]		
	In stalls	On concrete	Total
44" stalls			
Heifers	25	37	62
Light steers	16	52	68
Heavy steers	20	52	72
Average	21	47	67
48" stalls			
Heifers	16	49	65
Light steers	11	65	76
Heavy steers	9	64	73
Average	12	59	71
52" stalls			
Heifers	13	54	67
Light steers	9	59	68
Heavy steers	17	53	70
Average	13	55	68

[a]Based on daily observations made at random times between 6:00 a.m. and 8:30 p.m.

TABLE 28. Effects of loafing stall length on the resting behavior of three types of feeder cattle (Trial 2)

	Percent resting[a]		
	In stalls	On concrete	Total
44" stalls			
Heifers	34	30	64
Light steers	54	30	84
Heavy steers	47	19	66
Average	44	26	71
48" stalls			
Heifers	56	11	67
Light steers	59	20	79
Heavy steers	47	20	67
Average	54	17	71
52" stalls			
Heifers	53	12	65
Light steers	53	23	76
Heavy steers	47	21	68
Average	51	22	70

[a]Based on daily observations made at random times between 6:00 a.m. and 8:30 p.m.

VITA

John Albert Allen, Jr. was born in Putnam County, Cookeville, Tennessee on March 13, 1945.

After completion of high school at Cookeville Central High, he entered Tennessee Technological University, Cookeville, Tennessee, pursuing a Bachelor of Science Degree in Animal Husbandry. While at Tennessee Tech he was a member of the Block and Bridle Club, Tennessee Tech Aggies, and National Society of Agronomy. Graduating in 1967, he entered the University of Tennessee Graduate School to attain a Master's degree in Animal Husbandry, in the area of beef cattle production.

Presently he is a member of the 844th Engineer Battallion (Const) of the United States Army Reserves and plans to work for the Agricultural Extension Service upon completion of his Master's degree.