A STATISTICAL STUDY OF THE PERFORMANCE OF FEED-LOT STEERS

By

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INTRODUCTION

In cattle group-feeding trials, the relative value of rations or feed ingredients is measured in terms of weight increase or difference in value of the finished animals. Cattle feeding research has progressed to the point that we are now concerned with micronutrients or nutrients from different sources which we expect to give only small differences in gain. The problem of statistically showing that a treatment of economic importance has a small but consistent effect has been encountered at this and other stations

Experimenters, being aware that factors other than the test rations may affect gain and finish, have cautiously balanced lots of cattle at the initiation of the feeding period with regard to initial weight, sex, and feeder grade. Often such data as previous gain, source or previous treatment, sire, and dam productivity are available and can be used in allottment. If these factors reduce the between-lot variation, they increase within-lot variation and reduce the possibility of showing a significant difference The relationship of some of these factors to gain has been presumed to be substantial, although little data is available at this time From data accumulated in two feeding trials at this station, a statistical investigation was made of the relationship of initial weight, initial grade, previous gain, and gains during the early part of the feeding period to gain in the feed-lot and final grade attained

by the animals for the purpose of improving experimental efficiency. Consideration was also given to sample size and the relative merit of shrinking cattle before obtaining initial and final weights.

REVIEW OF LITERATURE

The review of literature is divided into seven major parts, corresponding to the procedure of reporting data in the results and discussion section of the thesis.

Only the literature believed to pertain directly to the study reported herein have been cited.

Comparisons of Weight with Grades

Knapp (1939), using data from 167 steers, expressed the relationship of live weight and grade by means of an algebraic formula for determining grade. The formula (Grade = -223.2839 - 3.5853H + 157.9825 log W) related grade to weight and height at the withers and was as accurate as the estimate of untrained judges. Rollins and Wagnon (1956) with 577 calves determined a within years correlation of .42 between weaning weight and weaning grade. These calves were produced in two grade herds of similar breeding. The herds were managed alike except that in one herd (A), the cows were supplemented during the fall and winter when the range was nutritionally deficient. On the basis of paternal half-sib relationship, heritability estimates were made within each of three generations for each herd. The estimates for herd A were consistently, but not significantly, higher than for herd B, indicating

that a more variable nutritional plane reduced the heritability estimate.

Kidwell and McCormick (1956) studied the influence of size and type on growth, development, feed-lot performance and carcass characteristics with 35 "conventional" Herefords and 39 Holstein steers. The data indicated that within the Holstein, but not the Herefords, grade was highly associated with weight. Wythe et al. (1956) separated 929 Hereford and Aberdeen Angus calves into groups according to grade at weaning. They found a definite advantage in weight for calves of the higher grades over the lower grades. All calves grading fancy had an average weaning weight of 442 pounds, as compared to 413 pounds for all calves grading good.

Thus it appears that the weight and the grade of an animal are positively correlated.

Comparison of Weight with Gain

Severson and Gerlaugh (1917) fed 216 steers for 140 days over a three-year period. They took 24 body measurements to try to determine a way of predicting gain. None of the body measurements were highly correlated with gain. Initial weight and gain did not appear to be correlated ($r = .04$). Lush (1931) studied the ability of several individual judges to predict gains. The estimates of gain by the judges were highly correlated with initial weight but were a little better estimate of gain than was initial weight. Initial weight and gains were only slightly correlated ($r = .24$ with 233 degrees of freedom). Lush (1932)

later determined initial weight and gain to be related to the extent that $r = .32$ with 166 degrees of freedom.

Concerning records of performance, Winters and McMahon (1933) suggest that weight at one year of age and a score on type and thickness of flesh be used for evaluating breeding animals. In a three-year study of steer calves from 75 grade Hereford cows by three pure-bred bulls, Stanley and McCall (1945) found weaning weight and daily gain to be significantly correlated ($r = .40$) between steers by the same sire. If the sire effect was not removed, the correlation ($r = .35$) was less, but still significant. They also published data on approximately 500 commercial steers which were about one-year old in February when placed on feed for 87-120 days. The correlation of initial weight and daily gain of these steers was -.06.

Knox and Koger (1946) reported correlations based on approximately 350 grade Hereford steers used in feeding experiments from 1937 to 1945 inclusive. The cattle were produced on the experimental ranch in New Mexico and were placed on feed approximately 12 months after weaning. Initial feed-lot weight and feed-lot gain was significantly correlated ($r = .24$). Koger and Knox (1951) reported later on 424 steers produced by grade Hereford cattle on semi-desert range and sired by 68 bulls in 13 years. Within sire groups, uncorrelated weaning weight showed a significant negative correlation of .16 with yearling gain, and showed no significant relationship to feed-lot gain. Correlation of yearling weight corrected for age of calf was nega-

tively and not significantly correlated with yearling gain ($r = -.08$), while with feed-lot gain the coefficient was significant and positive ($r = .19$). The additional correction for age of dam resulted in a higher correlation of weaning weight with feed-lot gain ($r = .27$) and a nonsignificant positive correlation with yearling gain. Long yearling weight and feed-lot gain were significantly correlated ($r = .39$); sires ignored, the correlation of long yearling weight and yearling gain was less ($r = .25$). Data on approximately 250 heifers kept for breeding, showed similar correlations.

Mott and Miles (1946) concluded from a study of the relationship of the weight of steers in the spring and the gains made during the summer grazing season, that less than one percent of the variation in gains made by steers on pasture was accounted for by initial weight.

Ruby et al. (1948) published results of correlations of weights and gains obtained on 959 Hereford calves at the Valentine substation in Nebraska in 28 seasons during the years 1927 through 1946. The calves were bought at weaning time from Sandhill ranchers and placed in wintering lots, usually in November. Correlation coefficients computed were: .232 for initial weight (fall) and winter gain; -.144 for initial weight (fall) and the following summer gain; .099 for initial weight (fall) and total gain, and -.371 for spring weight and summer gain.

Black and Knapp (1936) weaned calves at a weight-constant age (252 days) and slaughtered at a constant weight (900 pounds). The data consisted of complete records on 14 beef Shorthorn calves. The conclusion

was that the test period for measuring records of performance should be limited to a weight constant period and that the final evaluation should be based on efficiency of gain during this period and on carcass grade. Knapp et al. (1942) found that initial weight and feed-lot gain accounted for 80% of the differences in carcass grade of 62 individually fed steers. Knapp and Baker (1944) reported that much of the accuracy in predicting efficiency of gain from daily gain is lost if wide variation exists between individuals in initial and final weights.

Botkin (1952) obtained weights and winter gains from 386 steer calves and 219 heifer calves during the period 1944 through 1950. He also obtained data on 470 steer calves on full feed in the period 1942 through 1951. He found the following intra-lot correlations to be highly significant: Between initial weight and winter gain ($r = .14$); between spring weight and summer gain ($r = .45$), and between initial weight and gain in the feed-lot ($r = .24$). Correlation coefficients were not significant between initial weight and summer gain ($r = .08$) and between initial weight and total gain ($r = -.05$).

Lynn et al. (1956) did not find initial weight and total gain (winter and summer) of 198 steers to be associated.

It appears from the literature that a correlation, perhaps as high as $r = .45$, might exist between initial weight and gain although they are not likely to be associated. There are indications that this relationship exists when animals are changed from one level of feed intake to another or from one method of feeding to another.

There are also indications that correction for sire effect and age may increase the correlation coefficient.

Comparison of Grade with Gain

Waters (1907) stated that the amount of finish on an animal affects rate and economy of gain. To accurately compare animals they must be equally fat. Munford (1911) reported on feeding trials on pasture over a five-year period involving 300 animals. In allotting to treatment he rejected all animals of unusual characteristics, either above or below the mean. In every case where accurate comparisons could be made, fatter animals at the beginning of the over-200-day feeding period were less efficient in utilization of grain Lush (1932) found that carcass grade and gain were highly correlated ($r = .59$, 166 degrees of freedom).

Winters and McMahon (1933) found daily gain and selling price per 100 pounds to be highly correlated ($r = .52$). Hankins and Burk (1933) obtained data on 2073 cattle during three years from 18 state experiment stations. They found feed-lot gain and carcass grade to be highly correlated ($r = .66$)

Black and Knapp (1936) found that $r = .42$ for average daily gain and feeder grade. In a study of 2073 feeder cattle conducted by Hankins and Burk (1938) there was little or no relationship between feeder grade and subsequent gains of cattle in the feed lot ($r = .09$). There was a rather high correlation between feeder grade and the number of days required

to reach a certain slaughter grade. Knapp et al. (1941) found a correlation of .025 between weaning score and subsequent feed-lot gains of record-of-performance steers.

Knapp et al. (1942) later summarized data on 62 individually fed steers and reported that 80 percent of the differences in carcass grade could be accounted for by differences in initial weight and total gain while on feed. Stanley and McCall (1945) found that the rating of commercial steers as feeders was not a very good indication ($r = .196$) of the amount of gain made in the feed-lot. Sire-group calves showed little correlation ($r = .104$) between feeder grade and daily gain. Initial condition and daily gain were not correlated ($r = .066$). Patterson (1949) found that $r = .014$ between weaning type score and rate of gain in the feed lot. Knapp and Clark (1951) reported from a study based on 613 steers from 83 Hereford sires that the correlation between score and feed-lot gain was .00. A genetic correlation of .30 was concealed by an environmental correlation of -.304.

Although one author reported a correlation of .42, the literature indicates that there is little relationship between initial grade and subsequent feed-lot gain. From the work cited above, the correlation of gain and carcass grade is approximately .6.

Comparison of Different Grades

Hankins and Burk (1933) found that feeder grade and carcass grade of 2073 cattle were highly correlated ($r = .69$). Live grade and car-

cass grade were highly correlated (r = .86). They stated later (Hankins and Burk, 1938) that the feeder grade was an index of subsequent slaughter grade of steers.

Stanley and McCall (1945) studied data on 80 to 100 commercial steers fed approximately 170 days (and gaining approximately 350 pounds) in each of six years. These results indicated a highly significant correlation (r = .39) between feeder rating and carcass value. They found feeder grade not significantly correlated (r= -.05) with carcass grade.

Comparisons Between Gains in Different Periods

Waters (1907) concluded that gains on grass were inversely proportional to the amount of fat an animal carried when going on pasture. Gramlich (1928) reported that two-and three-year-old steers gained more rapidly during the second 100-day period. Sheets and Tuckwiller (1924) reported that the correlation between winter gains and total gains of two-year-old steers was .43. A negative correlation of -.57 resulted from a study of correlations between winter and summer gains.

Black and Knapp (1936) reported that average daily gain before weaning was negatively correlated (r = -.36) with average daily gain from weaning to slaughter. Ruby et al. (1948) reported that r = -.28 between winter gains and summer gains. Total gain and winter gain were highly correlated (r = .67). (Winter gain is a part of the total gain) Winters and McMahon (1933) stated that a four-month feeding

period is as short as can be recommended to obtain each animal's relative efficiency for record-of-performance registration. They state that a 28-day period would be about as efficient for comparison of animals if feeding in the same time period.

Knapp and Clark (1947) used records on 422 steers which were fed at least 252 days during the years 1937 to 1945. The feeding period was divided into three consecutive 84-day periods. Genetic influence in each of the three periods accounted for 10, 54 and 84 percent of the variation in gains. The correlation of gain in the first period with gains in the second period was .26; between the second period and the third r = .39; between the first period and the last period r = .18. The environmental correlations were .11 between the first and second period and -.32 between the second and third period. They concluded that there was little environmental correlation between the periods and the genetic influence became greater as the feeding period progressed. Koger and Knox (1951) found a significant positive correlation (r = .43) between yearling gain and feed-lot gain; sire effect ignored, the correlation coefficient was less (r = .17)

Botkin (1952) reported the following correlations between winter and summer gain from data on wintering management: high level of wintering, grazed all summer (r = -.40); high level of wintering, full-fed late summer (r = .09); medium level of wintering, grazed all summer (r = -.29); low level of wintering, grazed all summer (r = -.22); and low level of wintering, full-fed late summer (r = .16). Botkin also com-

puted other intra-lot correlation coefficients from additional data, as follows: Winter gain and early summer gain ($r = -.23$); winter gain and summer gain ($r = -.12$); first year gain of steers and second year gain ($r = .08$); and first year gain of heifers and second year gain ($r = .44$).

Lynn et al. (1956) found no significant correlation between winter gains and gain on pasture the following summer.

The studies of Botkin (1954) and Knapp and Clark (1947) indicate that there is little correlation between gains of animals in two periods if the animals are not changed from one level of nutrition to another and if they have adjusted to the environment. Some of the correlations between gains in different periods are rather high ($r = -.57$). Thus the growth impulse seems to express itself differently under different environmental conditions.

Comparison of Different Weights

Botkin (1952) found that initial weight and spring weight were highly correlated ($r = .78$). The correlation coefficient of initial weight and final weight was .73. Spring weight and final weight were correlated to the extent that $r = .84$. Yearling weight and two-year old weight were highly correlated ($r = .81$).

Ruby et al. (1948) with 959 Hereford calves found a correlation of .480 between initial weight (November) and subsequent spring weight.

Final weight and initial weight were correlated to the extent of .886. Spring weight and final weight were related to the extent that r = .863.

Lynn et al. (1956) found a positive correlation between initial weight and final weight of stocker steers.

Other Considerations

Stanley and McCall (1945) reported that quiet steers rated an advantage over wild steers both in daily gain and carcass grade (daily gains were 2.45 vs. 2.34 pounds, respectively). Winters and McMahon (1933) found that larger individual stalls had no effect on performance of individually fed steers. There was no difference in rate of gain of individually fed steers and group fed steers when overfeeding and weighing back the excess.

Knapp et al. (1942) in agreement with earlier work found that at least 8 individually fed animals were needed to test a sire's transmitting ability.

EXPERIMENTAL

The data used in this study were taken from four winter feeding trials involving 249 yearling steers at the Fort Reno Experiment Station, and five trials involving feed-lot performance data on 365 weaning steer calves at the experimental feeding pens located at Stillwater. The yearling steers were full-fed silage for 165 days, with limited amounts of milo and various supplements. The calves were full-fed milo for 160-165 days, with various supplements and a limited amount of silage. A detailed description of rations and the method of handling the cattle has been reported in yearly Feeders' Day Reports as indicated.

Source of Data on Yearling Steers

In the fall of 1953, a project was initiated at the Fort Reno Experiment Station to compare the relative value of protein supplements in rations containing sorghum silage and limited amounts of grain. Prairie hay and oat hay were also compared to sorghum as roughages; the steers were fed for 150 days on a full-feed of roughage and received an average of eight pounds of grain per head daily.

Fourty-eight, choice, yearling Hereford steers were purchased

from a Beaver county ranch in late October. They were an extremely uniform group, selected out of nearly 300 head, but were in rather thin condition. A week after arrival at the Fort Reno station, they were divided into four uniform lots of 12 head each on the basis of body weight and grade (Pope et al., 1954b).

In August, 1954, seventy, good-to-choice, yearling Hereford steers were obtained from the Experiment Station herds at Guthrie and Coalgate. They had been used during the previous year in pasture studies. Upon arrival at the Fort Reno Experiment Station, the yearlings were allowed to graze native grass and were fed from 2-5 pounds of supplement per head daily. The summer of 1954 was extremely dry and the pasture conditions were considered below average, although the cattle were in fair feeder flesh at the start of the test. The cattle were divided into seven uniform lots on the basis of source, gain during the previous pasture season, shrunk weight, and grade (Pope, et al., 1955b).

The third feeding trial from which the data on yearling steers was obtained involved seventy, coming two-year old Hereford steers obtained from the Experiment Station herds at Guthrie and Coalgate. The cattle had been purchased the previous fall from an Osage county rancher as long-aged calves, and had been used in pasture utilization trials in the summer of 1955. Their total gains during the previous year, considering location and treatment, were

available and were used in allotting them to the feeding test along with shrunk weight (16 hours off feed and water) and feeder grade (Pope et al., 1956b).

The fourth trial consisted of 70 long yearling steers from the Experiment Station herds at Guthrie and Lake Carl Blackwell. The 42 steers obtained from Guthrie had been purchased the previous fall from a rancher at Paoli in the southern part of the state. They were used in grazing trials at the Guthrie station. One-half of the 28 cattle from the Blackwell group had been implanted with 45 mg. of stilbestrol in June, 1946. Allotment to the feeding test at Fort Reno was made on the basis of source, previous treatment, summer gain, shrunk weight (off feed and water for 16 hours) and feeder grade (Pope et al., 1957b).

Source of Data on Steer Calves

In the fall of 1952, 80 head of choice steer calves were obtained from a ranch near Pawhuska in the northeastern section of the state, and from the Experiment Station herd. On arrival at the Experimental Steer Shed at Stillwater the calves were given oat hay and prairie hay, free-choice. After a few days, they were started on silage and a small amount of cottonseed meal and grain.

The feeding trial was started approximately 2 1/2 weeks after the calves arrived at the shed. They were divided into eight uniform lots of 10 head each on the basis of source, feeder

grade, and body weight. An average of 2 consecutive afternoon weights was used in establishing the initial and final weights (Pope et al., 1953).

The 1953 test involved 80 choice Hereford steer calves, part of which were purchased at the Ardmore Feeder Calf Sale and the remainder obtained from the Fort Reno Experiment Station herd. They were drenched with phenothiazine upon arrival at the feeding shed at Stillwater and were given about three weeks to recover from weaning and become accustomed to the change in feed (Pope et al., 1954a).

In 1954, ninety, good-to-choice, Hereford steer calves were used in the feeding trials. Thirty-six calves were selected from a drove purchased from an Osage county rancher; the remainder came from the Experiment station herd at Fort Reno. In the group from the experimental herd, most of the calves were sired by four purebred bulls (Pope et al., 1955a).

In the fall of 1955, 90 choice Hereford steer calves were selected from the experimental herd and from a group purchased through the Woodward Feeder Calf Sale consigned by a rancher in the western part of the state. They were given approximately four weeks to recover from weaning and shipment, and to become accustomed to the change in feeds (Pope et al., 1956a).

In the experiment initiated in the fall of 1956, 40 uniform Hereford steer calves were selected from the Experiment Station herds at Wilburton and Fort Reno. The calves were weaned in early October and allowed 3 weeks to recover from the effect of weaning and

to become accustomed to the feeds to be used in the trial (Pope et. al., 1957a).

Explanation of Terms

The measurements and scores used in this analysis are indicated below. The number of the variables in the analysis is given in the method of analysis.

1. "Initial weights" were taken at the beginning of the feeding period. During the first year of the calf experiment, the "initial weight" was an average of weights taken on three consecutive afternoons. All other "initial weights' were taken after holding the animals off feed and water for 16 hours.
2. The "intermediate weight" was taken without shrink, approximately seven weeks after the beginning of the feeding period for both calves and yearling.
3. "Final full weight" was taken without shrink at the end of the 160-165 day feeding period.
4. "Final shrunk weight" was taken with 16 hours shrink on the day after "final full weight".
5. "Early period gain" was determined by subtracting "initial weight" from "intermediate weight".
6. "Subsequent gain" was determined by subtracting "intermediate weight" from "final shrunk weight".

7. "Feed-lot gain" was "final shrunk weight" minus "initial weight".
8. The "previous gain" was made by yearlings while on pasture the summer preceeding the feeding trials.
9. "Overnight shrink" was obtained by subtracting "final shrunk weight" from "final full weight".
10. "Initial feeder grade" was assigned to all cattle by a committee at the beginning of the trial.
11. "Final live grade" was the slaughter grade assigned to the animals by a committee at the end of the feeding trial.
12. "First carcass grade" was an outside evaluation of the carcass, taken by a meats specialist before the carcass was ribbed down for the final grade.
13 "Final carcass grade" was taken by a meats specialist after ribbing down the carcass.

Grades were split into one-third grade. Smaller numerical values were assigned to the better grades. No correction for age or any other factor has been applied to the data. Lot (treatment) and year effect were removed by analysis All variables were not available in all years. Year designations in the data refer to the year the feeding trial began.

Method of Analysis

The data was analyzed by first recording all the information on each animal on forms supplied by the Oklahoma State University Computing Center. A card with all variables was punched for each animal. The information on the cards was then printed and double-checked for accuracy against the original recordings of the data in the field books.

The high speed computer (I.B.M. 650) calculated the correlation coefficients for each lot. This was done with program Cor III-A (filed in the Oklahoma State University Computing Center Library) Corrected sum-of-squares from each lot were pooled with program Cor II to get the yearly correlation coefficients. The author then pooled the corrected sum-of-squares and computed the overall correlation coefficients. This method of analysis removed the lot (treatment) effect and the year effect. The method is more accurate than pooling "r" values by using the "z" transformation.

RESULTS AND DISCUSSION

Comparison of Weight with Grade

Correlation coefficients of weights and grades for calves and yearlings are given in Table I. Unless otherwise indicated, the correlation coefficients given in the discussion below are overall. Since initial weight is taken at the beginning of a feeding trial, the relationship of this measure to initial grade is of interest. In the two years that initial grade was recorded for the yearlings, it was rather highly correlated with initial weight ($r = .39$ and $.58$) The calves showed yearly correlation coefficients that varied from .25 to .58, with an overall correlation of .42. This is in agreement with the findings of Rollins and Wagnon (1956) and Wythe et al., (1956) who found weight and grade at weaning to be associated.

The correlation of initial weight and final live grade was rather high ($r = .51$) for the yearlings, but much lower ($r = .26$) for the calves. Since the calves did not show a consistent year to year correlation, an investigation was made of the variances. However, the variance of grades in the years with small correlations was as large as in other years. This indicates a normal range in the grades assigned the calves The judges could possibly have been less influenced by size of calves than of yearlings. Possibly the milking ability of the dam influenced growth or finish of the calves so that the association of weight and grade

TABLE I. INTRA-LOT CORRELATIONS OF WEIGHT WITH GRADE

Items			Initial grade	Final live grade	First carcass grade	Final carcass grade
Initial weight	Yearlings	1953		.50		.34
		1954		.55		.23
		1955	.39	.43	.11	.15
		1956	.58			.19
		overall	.48	.51		.22
	Calves	1952	.58			
		1953	.24	.30		.06
		1954	.50	.48		.40
		1955	.28	-.07	.08	.02
		1956	.40	.31		.03
		overall	.42	.26		.16
Intermediate weight	Yearlings	1953		.50		.43
		1954		.59		.26
		1955	.28	.46	.16	.13
		1956	.39			.25
		overall	.33	.54		.26
	Calves	1952	.49			
		1953	.18	.33		.12
		1954	.45	.45		.35
		1955	.25	-.01	.14	.11
		1956	.32	.37		.10
		overall	.35	.28		.19
Final full weight	Yearlings	1953		.57		.50
		1954		.56		.25
		1955	.18	.61	.26	.25
		overall		.57		.31
	Calves	1952	.46			
		1953	.04	.39		.22
		1954	.38	52		.36
		1955	.07	.16	.35	.24
		1956	.19	.48		.22
		overall	.24	.38		.26
Final shrunk weight	Yearlings	1953		.60		.53
		1954		.57		.26
		1955	.20	.60	.25	.24
		1956	.20			.21
		overall	.20	.58		.29
	Calves	1952				
		1953	.04	.39		.22
		1954	.38	.51		.36
		1955	.11	.16	.35	.24
		1956	.23	.49		.24
		overall	.20	.38		.27

was reduced. The smaller association of initial weight with final live grade is interesting when related to the fact that the calves showed a significant correlation between initial weight and feed-lot gain, whereas the yearlings showed no correlation of initial weight with gain. One would think that if initial weight of the calves were positively associated with feed-lot gain, the correlation of initial weight and final live grade should be higher for calves than yearlings instead of lower as is apparent from Table I.

Initial weight and final carcass grade were positively correlated ($r = .22$ for the yearlings and $r = .16$ for the calves). Although the carcass value is ultimately of concern, the feeder usually sells on live grade. These data indicate that several of the measures taken are highly related to live grade. The reason for the much lower relationships between initial weight and carcass grade is not apparent. Since most of the carcasses were in one of two grades, if the carcass judge emphasized some factor not highly associated with weight, gain, or live grade the correlations would be small. The animal husbandman may overemphasize conformation in assessing live slaughter grades.

Intermediate weight was correlated only slightly higher with final live grade ($r = .54$ and $.28$, respectively, for yearlings and calves) than was initial weight. The final weights were highly correlated with grade of the yearling steers ($r = .57$) but moderately in the calves ($r = .38$).

The larger correlation for yearlings might be explained by the fact that the yearlings were past the period of maximum growth, and differ-

ences in weight might reflect differences in finish. Age of the steers was not known. One would expect age to affect the individual yearlings less than the calves. Since both calves and yearlings were born in a comparable period each year, they had a comparable standard deviation of age. The coefficient of variation of age of the yearlings was probably less than that for the calves due to a larger mean age.

These data indicate that the relationship ($r = .5$) between initial weight and the final live grade of yearlings should be considered if an experimenter is planning to place a monetary value on the steers at the end of the feeding period. The square of the correlation of initial weight and final live grade of the yearlings was .26, indicating that initial weight accounts for 26 percent of the variation in final live grade.

Comparison of Weight with Gain

Many correlation coefficients of initial weight and gain have been reported. Some have been significantly positive, while others have been significantly negative. The literature implies that individual steers may vary in response to different nutritional levels. Table II shows the correlation coefficients obtained between weights and gains in this study.

The yearlings showed no overall correlation of initial weight with feed-lot gain. However, the yearly correlations were quite variable and no consistent pattern could be observed. If there is no association of weight with future gain, it would appear that the correlation that

TABLE II. INTRA-LOT CORRELATIONS OF WEIGHT WITH GAIN

Items			Early period gain	Subsequent gain	Feedlot gain	Previous gain
Initial weight	Yearlings	1953	.26	-.16	.07	
		1954	-.10	-.22	-.21	.69
		1955	.18	.33	.34	.19
		1956	-.15	-.04	-.10	.61
		overall	.00	-.02	-.01	.53
	Calves	1952	-.02	.11	.09	
		1953	.36	.23	.34	
		1954	.24	.08	.19	
		1955	.28	.01	.13	
		1956	.45	.17	.33	
		overall	.23	.11	.19	
Intermediate weight	Yearlings	1953	.65	-.05	.40	
		1954	.22	-.15	.02	.56
		1955	.56	.37	.55	.14
		1956	.28	.03	.16	.40
		overall	.39	.05	.25	.39
	Calves	1952	.38	.07	.26	
		1953	.67	.27	.49	
		1954	.59	.12	.41	
		1955	.59	.09	.32	
		1956	.67	.29	.51	
		overall	.56	.14	.38	
Final full weight	Yearlings	1953	.66	.34	.66	
		1954	.29	.24	.34	.44
		1955	.50	.76	.84	.13
		overall	.46	.50	.62	.29
	Calves	1952	.26	.61	.68	
		1953	.56	.73	.84	
		1954	.53	.57	.73	
		1955	.59	.64	.77	
		1956	.73	.63	.78	
		overall	.51	.63	.76	
Final shrunk weight	Yearlings	1953	.68	.35	.68	
		1954	.29	.23	.34	.45
		1955	.50	.76	.83	.14
		1956	.31	.58	.61	.28
		overall	.42	.52	.62	.29
	Calves	1953	.58	.74	.85	
		1954	.55	.56	.73	
		1955	.58	.63	.76	
		1956	.74	.61	.76	
		overall	.59	.63	.77	

might exist in the early period would become less in the subsequent period. The yearlings had previously been treated very similarly in 1954 and 1955. The fact that the association became more negative in one year and more positive in the other, indicates that the relationship of weight and grade needs more study.

Intermediate weight and subsequent gain of the yearlings were slightly higher correlated than were initial weight and subsequent gain. This was true in all years and was probably due to the fact that intermediate weight was taken at the beginning of the subsequent gaining period. The calves did not show the consistent year to year higher positive relationship, but initial weight and intermediate weight were overall more highly correlated ($r = .14$ and $.11$, respectively) with subsequent gain. One might hypothesize that this is an indication that the longer animals are on feed, the more their gaining ability on full-feed is reflected in their weight. This would cause a higher correlation. Supporting this hypothesis is the fact the feed-lot gain is highly correlated with final weight. Also, previous gain and initial weight of the yearlings were highly correlated ($r = .53$). However, there is little evidence that future gaining ability can be well predicted from either initial or intermediate weight if animals are reasonably uniform. The high correlation between a weight and a previous gain is explained by the fact that the gain is a part of the weight.

One might expect calves to show a negative correlation between initial weight and feed-lot gain because the calves had just been weaned.

However, the larger calves may have been better suited to feed-lot conditions than the smaller, and possibly younger, calves. This could have offset the effects of finish or condition at the start of the trial, as reflected in the initial weight of the calves.

The square of the yearly correlation coefficients of initial weight and gain indicates that little of the variation in feed-lot gain is due to initial weight. This is true of early period gains of the yearlings (r^2= .07, .01, .03, and .02), and of the calves (r^2= .04, .13, .06, .08 and .20). The values are less for subsequent gain of the yearlings (r^2 = .03, .05, .11, and .00) and calves (r^2= .01, .05, .01, .00, and .03).

Thus with steers as uniform as the ones used in this study, the experimenter is not likely to appreciably decrease the variation in gain between lots by alloting on the basis of initial weight.

Comparison of Grade with Gain

The correlation coefficients between feed-lot gain and carcass grade reported in the literature are high. The data shown in Table III indicate a correlation of approximately .3 between feed-lot gain and final live grade. The correlation of feed-lot gain and final carcass grade is less (r= .19 for the yearlings and .26 for the calves).

Most of the studies of initial feeder grade and feed-lot gain indicate little association. The yearlings showed a negative correlation of initial feeder grade with early period gain (r = -.26). This relation-

TABLE III. INTRA-LOT CORRELATIONS OF GRADE WITH GAIN

Items			Initial feeder grade	Final live grade	Final carcass grade	First carcass grade
Early period gain	Yearlings	1953		.24	.36	
		1954		.16	.08	
		1955	-.12	.24	.01	.16
		1956	-.40		.13	
		overall	-.26	.20	.15	
	Calves	1952	-.11			
		1953	-.02	.24	.18	
		1954	.08	.12	.05	
		1955	.06	.12	.26	
		1956	-.03	.37	.26	
		overall	.00	.18	.16	
Subsequent gain	Yearlings	1953		.32	.32	
		1954		-.03	.03	
		1955	.00	.57	.29	.28
		1956	-.21		.02	
		overall	-.10	.29	.15	
	Calves	1952	.13			
		1953	-.16	.28	.24	
		1954	.02	.30	.15	
		1955	-.16	.31	.28	
		1956	-.11	.47	.43	
		overall	-.04	.31	.24	
Feed-lot gain	Yearlings	1953		.37	.45	
		1954		.07	.07	
		1955	-.05	.56	.24	.30
		1956	-.37		.08	
		overall	-.20	.31	.19	
	Calves	1952	.06			
		1953	-.14	.33	.27	
		1954	.06	.30	.14	
		1955	-.10	.30	.34	
		1956	-.09	.50	.42	
		overall	-.03	.33	.26	
Previous gain	Yearlings	1954		.45	.00	
		1955	-.08	-.03	.07	-.17
		1956	.56		.12	
		overall	.21	.25	.07	

ship becomes less negative in the subsequent gain period (r = -.10). The calves did not show any trend as to increasing or decreasing correlation from the early period gain (r = .00) to the subsequent period (r= .04). This might be explained on the basis that the gains of the calves were less influenced by finish at the start of the trial than were the gains of the yearlings which were approaching mature size. Since the calves had a large proportion of their growth potential remaining at the beginning of the feeding period, the influence of finish was not reflected in a negative correlation between grade and gain.

The calves were in good flesh when placed on feed. The correlation coefficients indicate that there is not likely any association of grade and later gains of calves of this type under the condition of this study. However, in the year 1956, initial grade of the yearlings showed highly negative correlation with early period gains (r = -.40) and with subsequent gains (r = -.21). The lower grade yearlings from the drouth-stricken pasture experiments made more rapid gains, particularly early in the feeding period.

Feed-lot gains were made prior to taking the final live grade or final carcass grade. These gains contribute to final live grade and final carcass grade. Both subsequent gain and feed-lot gain were correlated with final live grade approximately .3 and with carcass grade approximately .2.

From these data and those reported in the literature, it appears

that as far as feed-lot gains is concerned there is little advantage in considering initial grade when allotting steers in good flesh which are gaining rapidly.

Comparison of Different Grades

The correlation coefficients of grades are shown in Table IV. Initial grade and final live grade were highly correlated for the calves ($r = .40$) and the yearlings ($r = .44$). The calves showed little yearly deviation from .40. Data were available for only one year on the yearlings.

The comparison of final live grade and final carcass grade gave an overall correlation of .40 for the calves with fairly consistent yearly correlations. The overall correlation for this comparison with the yearlings was .42, with yearly values ranging from .18 to .76. An examination of the variances showed a small variance for final carcass grade in 1954 and a small variance for both final carcass grade and final live grade in 1955. Thus the lack of discrimination in the first carcass appraisal in 1954 may have caused the low correlation ($r = .18$) of final live grade and final carcass grade. The greater variation of values of both final live grade and final carcass grade probably caused the very high correlation in 1953.

The above correlations between feeder grades and carcass grades correspond with those obtained by Stanley and McCall (1954). Hankins and Burk (1933) found higher correlations. One would expect higher

TABLE IV. INTRA-LOT CORRELATIONS OF GRADES

Items			Final live grade	First carcass grade	Final carcass grade
Initial feeder grade	Yearlings	1955	.44	.14	.21
		1956			.20
		overall			.20
	Calves	1953	.40		.03
		1954	.41		20
		1955	.34	.19	.06
		1956	.48		.14
		overall	.40		.10
Final live grade	Yearlings	1953			.76
		1954			.18
		1955		.41	.43
		overall			.43
	Calves	1953			.47
		1954			.39
		1955		.50	.30
		1956			.46
		overall			.40
First carcass grade	Yearlings	1955			.43
	Calves	1955			.68

correlations if the steers were less uniform than those used in this trial.

The correlations obtained in this study indicate that initial grade should be considered in allotting steers to treatment if differences in final grade are attributed to treatment effect.

Comparison of Gains in Different Periods

The correlation coefficients between gains are shown in Table V. Previous gain of the yearling steers was negatively correlated with feed-lot gain ($r = -.21$). In agreement with the findings of Knapp and Clark (1947), there was less correlation between previous gain and subsequent gain ($r = -.08$) than between previous gain and early period gain ($r = -.30$). Early period gain was not highly correlated with subsequent gain for either the yearlings ($r = .18$) or the calves ($r = .15$). The calves showed a greater range of yearly correlation coefficients than the yearlings.

Other workers cited have shown varying relationships between gains in different seasons. Knapp and Clark (1947) concluded that the genetic influence became greater as the feeding period progressed. These data imply that individual animals do not grow at the same rate, proportionately, on different nutritional levels. Apparently steers are quite variable and individuals possess varying potential for growth in different environments. For example, individual A might

TABLE V. INTRA-LOT CORRELATIONS OF GAINS IN DIFFERENT PERIODS

Items			Subsequent gain	Feed-lot gain	Previous gain
Early period gain	Yearlings	1953	.17	.78	
		1954	.19	.72	-.34
		1955	.22	.63	-.04
		1956	.15	.62	-.47
		overall	.18	.67	-.30
	Calves	1952	-.07	.44	
		1953	.21	.58	
		1954	.14	.65	
		1955	.21	.58	
		1956	.48	.79	
		overall	.15	.59	
Subsequent gain	Yearlings	1953		.75	
		1954		.82	-.28
		1955		.89	.09
		1956		.87	-.09
		overall		.85	-.08
	Calves	1952		.86	
		1953		.92	
		1954		.84	
		1955		.92	
		1956		.91	
		overall		.89	
Feed-lot gain	Yearlings	1954			-.40
		1955			.05
		1956			-.30
		overall			-.21

be a slow gainer on any treatment; Individual B might not do well if on pasture or on a wintering ration, but compensates for this in the feed-lot. Individual C may be a fast gaining animal either on pasture or in the feed-lot.

Comparison of Different Weights

The correlation coefficients between initial, intermediate, final full and final shrunk weight are shown in Table VI. All of the correlation coefficients shown in the table are high due to the fact that an earlier weight is a part of a later weight.

The variances of final full weight and final shrunk weight were not significantly different; although on an overall basis it approached significance at the .25 level of probability. By years, the variation of final shrunk weight was always less than for final full weight. The variation of full weight was 9 percent greater than shrunk weight of the yearlings and 8 percent greater for the calves. Three of the 38 lots of calves had a greater variation of shrunk weight than full weight. This probably occurred by chance. This reduction in variance compares with that reported by Whiteman et al. (1954), with steers weighed off grass.

Since the regression of final shrunk weight on final full weight was .03, the coefficient of variation (standard deviation/mean) was computed to compare the variances. The coefficients of variation of full

TABLE VI. INTRA-LOT CORRELATIONS OF DIFFERENT WEIGHTS

Items			Intermediate weight	Final full weight	Final shrunk weight
Initial weight	Yearlings	1953	.90	.78	.78
		1954	.95	.84	.85
		1955	.92	.80	.81
		1956	.91		.72
		overall	.92	.80	.78
	Calves	1952	.92	.79	
		1953	.93	.79	.78
		1954	.93	80	.81
		1955	.94	.72	.74
		1956	.96	.84	.86
		overall	.93	.78	.79
Intermediate weight	Yearlings	1953		.91	.92
		1954		.92	.93
		1955		.88	.89
		1956			.83
		overall		.89	.88
	Calves	1952		.83	
		1953		.85	.85
		1954		.88	.89
		1955		.81	.83
		1956		.92	.93
		overall		.85	.87
Final full weight	Yearlings	1953			.99
		1954			1.00-
		1955			1.00-
		overall			1.00-
	Calves	1953			.99
		1954			.99
		1955			.99
		1956			1.00-
		overall			.99

weight and shrunk weight of the yearlings for 1954 were .078 and .077, respectively, and for 1955, .0704 and .0699, respectively. The respective coefficients of variation of full weight and shrunk weight of the calves were: .0727 and .0719 in 1953; .0783 and .0795 in 1954; .0742 and .0731 in 1955, and .0882 and .0882 in 1956.

Although the variance of shrunk animals is less than that of full animals, the coefficients of variation indicate little or no advantage for shrinking feed-lot steers. Lush (1928) reported that the average of weights taken on 3 consecutive days reduced the variation 42% over the first weight. Baker et al., (1947) reported that the standard error was higher in succeeding weights with the first day having a lower standard error than the average. Patterson (1947) found that a three-day average reduced variation somewhat but that 11 animals with single-day weights were more efficient, as judged by a smaller standard error for animals, than 10 animals with 3-day weight. This applied to gains as well as to absolute weights. The data reported herein did not compare the variation of gain when shrunk weight was used and when full weight was used. Further studies are needed to determine whether shrinking reduces variation of gains.

Comparisons Involving Shrink

The correlation coefficients involving shrink are shown in Table VII. There is a slight positive relationship of shrink to weight, previous gains, and grade. Since weight, grade, and previous gains are associ-

TABLE VII. INTRA-LOT CORRELATIONS INVOLVING SHRINK

	Initial weight		Intermediate weight		Final full weight	
	Yearlings	Calves	Yearlings	Calves	Yearlings	Calves
1953	.18	.42	.17	.37	.30	.47
1954	.35	.10	.38	.07	.54	.29
1955	.23	.12	.28	.21	.49	.45
1956		.05		.01		.32
Overall	.27	.16	.29	.17	.45	.37
	Final shrunk weight		Previous gain		Early period gain	
	Yearlings	Calves	Yearlings	Calves	Yearlings	Calves
1953	.18	.38			.07	.08
1954	.45	.16	.14		.09	-.03
1955	.42	.35	-.07		.21	.32
1956		.24				.18
Overall	.37	.27	.05		.12	.11
	Subsequent gain		Previous gain		Early period gain	
	Yearlings	Calves	Yearlings	Calves	Yearlings	Calves
1953	.04	.23	.07	.22		-.04
1954	.22	.21	.21	.14		-.05
1955	.45	.32	.45	.40	.06	.31
1956		.42		.38		.40
Overall	.26	.27	.25	.26		.10
	Final live grade		First carcass grade		Final carcass grade	
	Yearlings	Calves	Yearlings	Calves	Yearlings	Calves
1953	.06	-.17			.08	-.14
1954	-.14	-.15			.00	-.05
1955	-.32	-.01	-.16	-.13	-.23	-.13
1956		-.07				-.18
Overall	-.13	-.11			-.04	-.08

ated, this slight positive correlation is expected. Kidwell and McCormick (1956) did not find shrink to be associated with grade of Holstein or Hereford steers.

Partial Correlation Coefficients

Partial correlation coefficients were not found to be high. The following partial correlation coefficients were determined for the calves:

1. Initial weight, feed-lot gain - initial grade ($r = .20$)
2. Initial grade, final live grade - initial weight ($r = .33$)
3. Early period gain, subsequent gain - initial weight ($r = .13$)
4. Intermediate weight, subsequent gain - early period gain ($r = .07$)
5. Final live grade, final carcass grade - final shrunk weight ($r = .34$)

For the yearlings, the following partial correlation coefficients were determined:

1. Initial weight, final carcass grade - initial grade ($r = .14$)
2. Early period gain, final carcass grade - initial grade ($r = .21$)
3. Early period gain, subsequent gain - initial grade ($r = .16$)
4. Final live grade, final carcass grade - final shrunk weight ($r = .33$)

Holding a variable constant increased the correlation only with the comparison of initial weight and feed-lot gain of the calves when initial grade was held constant. The correlations between initial weight and

feed-lot gain was .19; between initial weight and initial grade .42, and between initial weight and feed-lot gain, the correlation was .03. Thus, the correlations between related variables were not high enough to increase the partial correlations.

Sample Size

The number of animals necessary in a feeding trial may be determined. Snedecor (1956) presents a formula for determining the sample size from the variance of previous studies. This formula gives the number of animals necessary per treatment to pick up a significant difference 75 percent of the time. The intra-lot variance of feed-lot gain of the calves was found to be 1705 (s = 41.28) with 327 degrees of freedom. The intra-lot variance of the yearlings was 2636 (s =51.34) with 224 degrees of freedom.

To statistically show a difference in five treatments at the five-percent level of probability 75 percent of the time would require 33 calves on each treatment with a difference in rate of gain of .2 pounds a day over a 160-day feeding period. Fourteen calves per treatment would be required to show a .3 pound per day difference 75 percent of the time at the 5 percent level of probability over a 160-day feeding period with 5 treatments. Similarly, 8 calves would be needed to show a difference of .4 pounds per day and six would be needed to show a .5 pound difference.

With yearling steers, to statistically show at the 5 percent level of

probability a .2 pound a day difference in gain 75 percent of the time with 5 treatments over a 160-day feeding period would require 53 yearlings on each treatment. A difference of .3 pound per day would require 28 yearlings per treatment. A .4 pound difference would require 15 yearlings. Only 10 animals would be required to show a .5 pound difference in rate of gain with the above conditions.

Snedecor (1956) shows that error due to sampling may be reduced by (1) increasing sample size, (2) selecting or developing populations in which variation is known to be small, (3) subdividing the aggregates into sub-populations or strata of similar individuals, and (4) utilizing information contained in related variables. Since increasing sample size is costly, the method of selecting a uniform group of steers for experimental purposes has been used. The results of this study indicate that stratifying the steers on initial weight and initial grade would be of benefit only as a means of reducing between-lot variation in final live grade.

SUMMARY

Data on the feed-lot performance of 249 yearling steers on fattening trials over a four-year period, and 365 weanling steer calves on fattening trials over a five-year period were statistically analyzed. The yearling steers were full-fed silage, with limited amounts of milo and various supplements for 165 days; the calves were full-fed milo with various supplements and small amounts of silage over a 150-185 day fattening period.

A correlation coefficient of .51 was found to exist between initial weight and final live grade of yearling steers The association between final live grade and weight became higher with weights taken near slaughter. Final live grade was correlated .54 with intermediate weight and .57 with final full weight The association of weight and grade of calves was not as high as that of yearlings. Correlation coefficients were determined for final live grade with initial weight ($r = .26$), with intermediate weight ($r = .28$), and with final weight ($r = .38$).

Little evidence was found to support the hypothesis that initial weight and future gain are strongly associated. The yearlings showed no overall correlation of initial weight with feed-lot gain. However, in some years there was a significant positive relationship and in other years a significant negative relationship. The calves showed a small posi-

tive relationship between weight and future gain.

Calves showed no relationship of initial feeder grade to gain; yearlings showed a small negative correlation ($r = -.20$). The relationship of initial grade and gain of the yearlings was less negative in the subsequent gain period ($r = -.10$). Feed-lot gain was correlated with final live grade approximately .3, and with carcass grade approximately .2. Initial feeder grade and final live grade were significantly correlated for the yearlings ($r = .40$) and the calves ($r = .44$). All of the correlation coefficients with carcass grade were small except final live grade ($r =$ approximately .4).

The variance of final shrunk weight was found to be less than for final full weight, although the coefficients of variation were approximately the same. A method of determining the number of replications necessary to detect a specified treatment difference was discussed.

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