Estimation of Total Feedlot Gain in Beef Cattle from Initial Weight, Initial Age and Early Gain[1]

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Feedlot data on three groups (designated E_1, E_2 and E_3) comprising 272 steers of Angus and Hereford breeds raised over a period of four years at Beef Experimental Stations of Iowa State University in Southern Iowa, U.S.A. were analysed. Attempts have been made to estimate total Feedlot gain (Y) considering initial weight (X_1), initial age (X_2), gain during first 28-day period (X_3), gain during second 28-day period (X_4), and gain during third 28-day period (X_5) as independent variables. The multiple correlation for group E_1 using all five independent variables was 0.725, while those for groups E_2 and E_3 using the first four variables were 0.766 and 0.724 respectively. The variables were tested sequentially in order as information became available in the life of the animals. The analyses of variance showed that including each additional variable, except for initial age, added significant amounts of information. It was concluded that total gain in beef cattle can be predicted with considerable success from initial weight and gains made in feedlot during the first two to three months. In similar populations and under conditions corresponding to the ones in this experiment, the multiple correlations are likely to be around 0.70-0.75.

INTRODUCTION

The importance of evaluating the breeding and growing potentialities of animals at an early age has long been recognized by livestock breeders. The fundamental purpose in livestock improvement is to develop strains of livestock that are more efficient in converting feeding stuffs into products useful to man. Rapid improvement is possible only when breeding stock can be selected at a fairly young age with great reliability. Much work has been done in all phases of beef production, but the information on predicting future gains from early growth is scanty. This is the most important aspect for increasing the efficiency of economy of the beef enterprise.

The objective of this study is to estimate and predict the total gains of beef cattle at different ages, considering the initial weight, age at the beginning of feeding period, and early gains during the first two or three months in the feedlot. The usual feedlot test varies from 140 days to 252 days depending on initial weight and age. If early information on feedlot performance is a good

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indicator of subsequent gains, this period can be reduced for selection of breeding stock.

REVIEW OF LITERATURE

One of the earliest studies reported is by Severson and Gerlaugh (1919) who calculated the simple correlation coefficients between a large number of body measurements and the gains which the steers subsequently made. These correlations were worked out without any correction for heterogeneity of data and probably would have been considerably different if such correction had been made. Nearly all the correlations were small. No attempt was made to combine the simple correlations into a multiple correlation so as to determine whether each measurement had a relation to gain largely independent of that involved in other measurements or whether the different measurements were expressions of nearly the same attribute of the steers.

Lush (1931, 1932) studied the relationship of body shape of feeder steers to rate of gains, dressing per cent and the value of the dressed carcass. He observed that individual gains, dressing percentage and commercial value of the carcass at the end of the fattening period can be predicted with only slight success at the beginning of the feeding period.

Winters and McMahon (1933) found a relatively high correlation between rate of gain and efficiency of feed utilization. They suggested that breeding animals be evaluated on weight at a year of age and on score for type and thickness of fleshing.

Hankins and Burk (1938) found no relationship between feeder grade and subsequent gains of cattle in the feedlot. Knapp *et al.* (1941) reported that daily gain may be used with a high degree of accuracy to predict efficiency of gain of animals fed through a comparable weight range but much of the accuracy might be lost when there is wide variation between individuals in initial and final weights.

Hazel *et al.* (1943) developed a method of working out genetic and environmental correlation between the growth rate of pigs at different ages. They analyzed the gross correlation between the gains of three 56-day periods from birth to 168 days and further worked out the genetic and environmental parts of the variance. The genetic correlations between the gains in adjacent periods were compared. The possibility of using gains from 56 to 112 days as a measure of hereditary growth rate in selecting boar pigs was suggested. Knapp and Clark (1947) adapted the same procedure to cattle data, and found statistically significant gross correlations of 0.26, 0.18 and 0.39 between three 84-day periods.

Bujatti (1956 a, b) considered the possibility of predicting liveweight at one year from the liveweight at six months in heifer calves of the Chiana breed and found the relationship to be curvilinear. Rognoni and Pasti (1958) worked out the correlation between birth weight and average liveweight increase during the first six months in Friesian and Brown Alpine calves. The correlation coefficients between the two factors were 0.013 in Friesian and 0.283 in the Brown Alpine, the latter being statistically significant.

Swiger (1961) studied the genetic and environmental influences on gains of beef cattle during various periods of life. He found that heritability of weaning weight was 0.25, of feedlot gains for 140 days was 0.40 and of weight at the age of one year was 0.47.

Swiger and Hazel (1961) studied the optimum length of feeding period in selecting for gains in beef cattle. They considered the effect of shortening the postweaning evaluation to about three months which would be adequate for selection for weight at one year of age.

MATERIAL AND METHOD

This study is based on the data recorded from 272 steers on feedlot. These were born and raised at the Beef Experimental Stations of Iowa State University in Southern Iowa (U.S.A.) during years 1958 through 1961. They were the progeny of 31 sires. About one-fourth of the total number were Angus while the rest were Hereford. They were weaned at the age of about seven months in November and were subdivided into three groups designated as E_1, E_2 and E_3. The design required placing an equal number of calves from each sire in each group but this was not possible in a few cases.

Group E_1 was transferred to the feedlot immediately after weaning (November) where they were given full feed of a fattening ration consisting of a high proportion of concentrates after an adjustment period of one month. They were taken off feed when they reached approximately 1000 lbs. in body weight. They remained on feed for 252-280 days when they were disposed off. The body weights were recorded at 28-day intervals.

Group E_2 and group E_3 were wintered on silage and hay. About one-half pound of soybean oil meal was fed per head as protein supplement. The quantities of this growing ration were adjusted so as to allow the animals to grow at an average rate of one pound daily.

During early summer, group E_2 was transferred to feedlot. After an adjustment period they were put on full feed. They remained on feed for a period of 140-168 days. It may be noted that these animals were fattened during summer months.

Group E_3 was grazed on pasture from about May 1 to the middle of October. The pasture available to them was blue grass, legumes and red clover varying a bit from time to time. These animals were transferred to feedlot during the month of October when they were about one and a half years old. After an adjustment period similar to E_1, they were put on full feed.

Groups E_1, E_2 and E_3 were raised to varying ages and weights before putting them on feed, so each group is considered separately throughout this study.

The data pertaining to each group (E_1, E_2 and E_3) were first analyzed separately for each year. The intra-year variances and covariances for each group being similar in magnitude were then pooled. Pooled means, variances and standard errors were then calculated. No distinction was made between Hereford and Angus in the calculations. The gains during each period were calculated by subtracting the body weight at the beginning of each period from the body weight 28 days later. The total gain in feedlot (Y=dependent variable) was calculated by subtracting the initial weight (X_1=independent variable) at the beginning of feeding trial from the final body weight. The initial age in days was considered as an independent variable (X_2) in the analysis. The gains in pounds during the first, second and third 28-day periods were designated as X_3, X_4 and X_5 respectively.

The method of linear multiple regression and multiple correlation given in standard textbooks on statistical method was employed. The normal equations were derived and values of partial regression coefficients (b_i) were obtained by solving them by abbreviated Doolittle Method. These values were converted to standard partial regression coefficients (b'_i). Since b'_i is independent of the original unit of measurement, the comparison of any two indicates the relative importance of the independent variable involved. Then multiple correlation coefficients were calculated. The statistical significance of each of the independent variables in the prediction of the dependent variables was tested by an appropriate "F" test in an analysis of variance.

The tests of the different variables were arranged in a sequential order according to the time when the information become available. That is, initial weight is readily available at the beginning of a feeding trial and initial age can be computed if birth dates are known. Hence these two variables were examined first. Gains during the successive 28-day period become available in the order tested.

RESULTS AND DISCUSSION

The pooled mean weights and variances for the three groups are given in Table 1. The variances of initial weight and age in group E_1 are the lowest as compared to the other groups. Age was more uniform because the calves born early in the spring were placed in this group. The weights of the E_2 and E_3 steers increased in variation during the periods which intervened between weaning and the start of feedlot test.

TABLE 1. *Mean and variance of initial weight, age and early gains.*

Group	No. of animals in each group	Initial weight (Pounds)		Initial age (days)		Gain during first 28-day period		Gain during second 28-day period		Gain during third 28 day period	
		Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance
E_1	96	483.4	3300.8	264.7	358.6	56.0	406.6	63.4	195.3	64.8	245.6
E_2	89	656.5	6132.5	435.1	563.1	57.8	278.4	70.0	337.5	..	..
E_3	87	777.7	6781.3	557.8	1314.5	80.4	835.4	69.8	394.9	...	...

As each of the three groups of animals were put on feedlot at different ages, they were considered separately throughout the analysis. Simple correlation coefficients between various variables in three groups are given in Table 2. In the present study all the simple correlations involving initial weight and age with other variables in group E_1 are non-significant. In group E_2 and E_3 the correlations between initial weight and total gain are positive and statistically significant. Probably the main reason for this is that the total gain of group E_1 was made over eight periods of 28 days while the total gains of the two other groups (E_2, E_3) were made over five similar periods. Thus, there was greater opportunity over the longer period to be influenced by factors other than initial weight.

The simple correlations between initial weight and initial age were positive for all three groups, varying from 0.35 to 0.48. This merely reflects the usual tendency for the older animals to be heavier. The only appreciable correlation between initial weight and the individual 28 days gains are those for gains in the second period for both the E_2 and E_3 groups.

It is perhaps not surprising that there is no evidence of compensatory gains in these data. That would be expected only if some of the steers had been subjected to severely limited feed intake for a considerable period. The steers in each group had been subjected to rather uniform treatment within groups prior to the start of full feeding, but without having been fed so well that later gains would be reduced. For example the groups E_2 and E_3 were wintered on ample roughage and limited grain so as to gain about one pound per day. The E_2 steers were started on full feed at the end of the winter and E_3 steers were grazed on good pasture during the summer. The fact that initial weight and feedlot gains were positively correlated show that the factors which caused the steers to gain differently earlier continued to have similar effects after the feedlot tests were started. This was noticeable in the two older groups in particular. The 28-day gains of the two older groups tended to be larger than those of the E_1 group, as is commonly observed for older steers (Table 1). Variance in gain was larger for the group E_3 and least for the group E_2 in the first 28-day period. This suggests that there is some irregularity and unevenness in adjusting to a full grain feeding programme after having been on pasture.

TABLE 2. *Simple correlation coefficients between various variables.*

		X_2 Initial age	X_3 Gain I	X_4 Gain II	X_5 Gain III	Y Total gain
E_1 (d. f.=92)						
Initial wt.	(X_1) ..	0.4760**	0.1067	0.0008	—0.0155	0.0892
Initial age	(X_2) ..		0.0264	—0.0084	—0.0564	—0.0816
Gain I	(X_3) ..			0.0662	0.1903	0.5662**
Gain II	(X_4) ..				—0.0551	0.3642**
Gain III	(X_5) ..					0.3817
E_2 (d. f.=85)						
Initial wt.	(X_1) ..	0.3468**	0.0589	0.2968**		0.3537**
Initial age	(X_2) ..		—0.1126	0.0799		0.0063
Gain I	(X_3) ..			0.0539		0.5638**
Gain II	(X_4) ..					0.5117
E_3 (d. f.=83)						
Initial wt.	(X_1) ..	0.4824**	0.0858	0.2391*		0.2969**
Initial age	(X_2) ..		—0.0053	0.1587		0.0335
Gain I	(X_3) ..			—0.1482		0.6002**
Gain II	(X_4) ..					0.2620**

*Significant at 5 per cent level.
**Significant at 1 per cent level.

The correlations between initial age and subsequent gains are non-significant within each of the three groups. The correlations are small and vary in signs, indicating that they are near zero. This cannot be interpreted broadly to mean that gains are not influenced by age. In this experiment the steers in each group were of rather uniform ages, since all were born in the spring and were started on feed on the same day later on. Under these conditions, the intra-group variation in age was too small to reflect any meaningful relationship. This was true even in the group E_3 which was most variable in age.

The correlations between the first 28-day gain and total gain over the feeding periods are highly significant, varying from 0.56 to 0.60 in all groups. This shows that the first gain is a good indicator of total gain. These correlations reflect the usual "part-whole" relationship which exists when one variable is an additive part of another. Most of the observed correlation between the first 28-day gain and total gain is due to this "part-whole" relationship, since the correlations between gains in adjacent periods vary from small positive to small negative values.

The correlations between the second 28-day gain and total gain vary from 0.26 to 0.51 and are highly significant in all groups. These correlation coefficients are smaller than those between first period gain and total gain. It may be noted in Table 1 that variance in the first period gains was considerably larger in group E_1 and E_3 than it was in the second period, while the reverse was true in group E_2. Due to the "part-whole" relationship to total gain, the second period gain appears to have considerably greater predictive value for estimating total gain in group E_2 than in the other groups.

Hazel, Baker and Reinmiller (1943) worked out the gross correlations between the gains of three 56-day periods from the birth to 168 days in pigs and suggested the possibility of using the gains from 56 to 112 days as a measure of hereditary growth rate for selection of boar pigs. Knapp and Clark (1947) used a similar procedure on cattle and studied correlation between gains made during each of 84 day periods. The simple correlation between periods 1 and 2 was 0.26, between periods 1 and 3 was 0.18 and between periods 2 and 3 was 0.30. All these correlations were statistically significant.

Koger and Knox (1951) found a positive relationship between the gains made at different periods when environment was similar for different animals. They further concluded that this relationship could be obscured or even reversed by variable conditions.

In a study on range cattle, Kidwell (1954) observed the relationship of gains made over a period of about two years after weaning. He worked out the correlation between four periods (Winter, Spring, Summer and next Winter).

A positive correlation was observed between gains made during the two winter periods. Correlation between succeeding periods were negative and significant, showing the environmental influences on the gains.

The standard partial regression coefficients are given in Table 3. These are independent of units of measurement and can be compared with each other. Snedecor (1961) called this a "quick and dirty" method of comparison.

TABLE 3. *Standard partial regression coefficients.*

	Independent variables.	b'_{X_1}	b'_{X_2}	b'_{X_3}	b'_{X_4}	b'_{X_5}
E_1	X_1, X_2	0.127	—0.079			
	X_1, X_2, X_3	0.059	—0.062	0.562		
	X_1, X_2, X_3, X_4	0.059	—0.058	0.540	0.328	
	X_1, X_2, X_3, X_4, X_5	0.062	—0.041	0.479	0.349	0.308
E_2	$X_1, X_2,$	0.399	—0.132			
	X_1, X_2, X_3	0.339	—0.050	0.538		
	X_1, X_2, X_3, X_4	0.211	−0.042	0.524	0.424	
E_3	X_1, X_2	0.365	—0.142			
	X_1, X_2, X_3	0.296	—0.106	0.598		
	X_1, X_2, X_3, X_4	0.225	—0.122	0.628	0.321	

As is apparent from the numerical values, these are largest for gain in the first 28-day period as compared to others and are most important in predicting the total gain. These were worked out using two independent variables (initial weight, initial age), three variables (initial weight, initial age, and gain during first 28-day period), four variables (initial weight, initial age, gain during first 28-day period and gain during second 28-day period), five variables (initial weight, initial age, gain during first 28-day period, gain during second 28-day period and gain during third 28-day period). In case of group E_1, all five variables were used but in groups E_2 and E_3 only the first two, first three and first four variables were used because the total feeding period in these cases was short. With all these standard partial regression coefficients, total gain is considered as the dependent variable. The coefficients for initial age are small in all combinations with other variables in each of the three groups. The coefficients for gain in the first 28-day period are somewhat larger than those for gain in the second 28-day period.

The values of the multiple correlation coefficients were calculated and are given in Table 4. These values vary from 0.573 to 0.666 in all three groups when three variables (initial weight, initial age and gain during first 28-day period) were considered.

TABLE 4. *Multiple correlation coefficients.*

Group	Using two independent variables	Using three independent variables	Using four independent variables	Using five independent variables
E_1 ..	0.133	0.573	0.660	0.725
E_2 ..	0.375	0.650	0.766	
E_3 ..	0.322	0.666	0.724	

In the group E_1 the proportion of variation in total gain associated with X_1, X_2 and X_3 is 32.8 per cent, while it is 42.3 and 44.4 per cent in groups E_2 and E_3 respectively. The proportion of variation in total gain associated with four independent variables (initial weight, initial age, gain during first 28-day period and gain during second 28-day period) X_2, X_3 and X_4 is 43.6, 58.7 and 52.4 per cent in groups E_1, E_2 and E_3 respectively. It means that addition of another variable added more information and made prediction more reliable.

To find out if including an additional variable changes the value of multiple correlation coefficients significantly, the analyses of variance in Table 5 have been constructed for E_1, E_2 and E_3 respectively.

The tests of the different variables were arranged in a sequential order according to the time when the information becomes available. That is, initial weight is readily available at the beginning of a feeding trial and initial age can be computed if birth dates are known. Hence, these two variables were examined first. Gains during the successive 28-day periods become available in the order tested.

Each test of significance was made by separating the "remaining" variance at each stage into a part attributable to reduction due to the next independent variable and an error for testing that reduction for statistical significance. Thus the reduction due to X_1, is $(r^2_{y.1}) \sum y^2$ and the appropriate error mean square is $(1-r^2_{y.1})\sum y^2/(n-2)$. The reduction due to X_2 after fitting X_1 is $(R^2_{12}-r^2_{y.1}) \sum y^2$ and the appropriate error mean square is $(1-R^2_{12}) \sum y^2/(n-3)$. The reduction due to X_3 after fitting X_1 and X_2 is $(R^2_{y.123}-R^2_{y.12}) \sum y^2$ and the appropriate error mean square is $(1-R^2_{y123}) \sum y^2/(n-4)$. The perusal of these tables will indicate that reductions due to regression on X_3, X_4 and X_5 are highly significant.

TABLE 5. *Test of significance of multiple correlation coefficients of total gain in feedlot on initial weight, age and early gains.*

Source of variation	Group E_1			Group E_2			Group E_3		
	Degree of Freedom	Sum of Squares	Mean Squares	Degree of Freedom	Sum of Squares	Mean Squares	Degree of Freedom	Sum of Squares	Mean Squares
Total ..	92	194951		85	124136		83	152720	
Reduction due to X_1 ..	1	1551	1551.0[NS]	1	15531	15531.0**	1	13465	13465.0**
Error (for testing X_1) ..	91	193400	2125.3	84	108605	1292.9	82	139255	1698.2
Reduction due to X_2 after fitting X_1 ..	1	1915	1915.0[NS]	1	1891	1891.0[NS]	1	2372	2372.0[NS]
Error (for testing X_2) ..	90	191485	2127.6	83	106714	1285.7	81	136883	1689.9
Reduction due to X_3 after fitting X_1 and X_2	1	60513	60513.0**	1	35098	35098.0**	1	51916	51916.0**
Error (for testing X_3) ..	89	130972	1471.2	82	71616	873.4	80	84967	1062.1
Reduction due to X_4 after fitting X_1, X_2 and X_3	1	20842	20842.0**	1	20316	20316.0**	1	12206	12206.0**
Error (for testing X_4) ..	88	110130	1251.5	81	51300	633.3	79	72761	921.0
Reduction due to X_5 after fitting X_1, X_2, X_3 and X_4	1	17496	17496.0**	...	...	—	...	...	—
Error (for testing X_5) ..	87	92634	1064.8	—	..	—	...	...	—

NS=Non-significant.

**Significant at the 1 per cent level.

The reductions due to regression on initial weight (X_1) and initial age (X_2) are non-significant in group E_1. The reduction due to regression on initial weight in group E_2 and E_3 are significant at the 1 per cent level, while the reductions due to initial age are non-significant in these groups.

This indicates that the initial weight of the steer is important in predicting feedlot gain. Initial age is not significantly important in this respect, but the groups were deliberately chosen so as to be rather uniform in age.

The results obtained in the present study are in full agreement with the suggestions made by Swiger and Hazel (1961) and further confirm that the postweaning evaluation periods may be shortened without serious loss of efficiency for selection for gaining ability, thus helping economical beef production.

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