SOME GENETIC AND ENVIRONMENTAL FACTORS ASSOCIATED WITH PERFORMANCE AND CARCASS TRAITS OF BEEF CATTLE

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INTRODUCTION

It is the foundation of genetics that individuals between and within families differ to a greater or lesser extent. The more closely related the individuals are, the more alike they appear and perform. When a purebred cattle operation closes its herd from outside breeding, that move is made in an attempt to make similarity work to advantage. Otherwise, there would be no need in closing the herd. Whether or not the breeder, through inbreeding tempered with selection, will have animals in his herd that are individually superior to any other animal in any other purebred herd matters little. The criterion on which animals are, or should be, judged is what these animals will do when used in the commercial production of beef. If the records subsequently show that these animals have performed to the financial advantage of the purchaser who is in the business of beef production over and above animals that have a genetic background other than that of a closed herd, then the closed herd animal breeder will have proved that his application of the foundation of genetics has real merit.

The present study will show some of the practical results obtained from the inception of a closed herd system of breeding, involving four genetically distinct Hereford lines of cattle, and carried over to a commercial system of beef production, the practical results being the evaluation of these lines by studying their progeny in this commercial system. Three of the lines mentioned are the Lionheart, Prince, and David, maintained as closed lines at the Oregon Agricultural Experiment Station, Corvallis, since 1948. The fourth line, sometimes referred to as the Union line, has also been a closed herd since 1948, and was obtained from an Eastern Oregon breeder. The animals from these four lines are bulls which are used in the commercial beef herd at the Eastern Oregon Branch Station, Union.

The study is designed to show not only the performance of these four lines, but the differences between them, reflecting their genetic potential in the different traits studied. It would be expected that different lines would have different strong and weak points, which would be reflected in the progeny of sires from these lines, disregarding the dam side.

The data available on the animals involved in this study also enables a means of analyzing the effects of different variables on the performance traits and carcass

characteristics of the progeny studied. This analysis will be discussed, as will some of the correlations that evolve from an analysis of this sort.

REVIEW OF LITERATURE

Performance and carcass characteristics have been the objects of intense study in the past and probably will continue to be in the future. The carcass, however, has of late received more and more attention. This is a natural step for one concerned with animal breeding, realizing that the quality of the product of his endeavors on the rail and on the plate is a measure of his ability to improve that product. Researchers have attempted to obtain measures of the associations between traits in cattle and to establish parameters that would be useful in selection.

Performance and Carcass Traits

A definite relationship exists between age of dam and birth weight of the calf, as concluded by Burris and Blunn (4). Their study showed that the maximum birth weight isn't reached until the cows are 9-10 years of age. The regression of birth weight on age of dam is highly significant. Sire effects on birth weight were insignificant, as were year effects, explained by uniform conditions of management from year to year.

Brown (3) studied the influence of year, season of birth, sex, sire, and age of dam on weights of beef calves at 60, 120, 180, and 240 days of age, in three

herds of cattle, two of which were purebred Angus and one, purebred Hereford. In the two Angus herds there was a decline in constants associated with years, probably because of bias in culling cows, rather than because of deterioration in environment during the years studied. An increase in weight of the calves was associated with an increase in age of dam during her earlier years of production and then a decline in calf-weight after her peak years of production. In this study the time required to reach mature production differed in the three herds. The Hereford herd and one Angus herd reached mature production by the third or fourth lactation. The other Angus herd reached mature production at the fifth or sixth lactation. In this latter herd the percentage of variation in weights at different ages due to the age of dam was 20 percent, which was higher than that for the other two herds.

The effect of birth weight, age of dam, and time of birth on suckling gains of beef calves was reported by Nelms and Bogart (21). The regression coefficient was .0115, indicating that for a change of 10 pounds in the weight there was associated a difference in rate of gain of .115 pounds per day. Contrary to some reports, there was no significant difference found in suckling gains between calves of two-year old dams and those of older cows.

Selection applied for suckling gains on the younger cows probably offset any difference, as the older cows were unselected as far as suckling gains were concerned. The time of birth had an equal or greater effect than age of dam on rate of suckling gains of the calves when the younger dams were selected for this trait, as compared to unselected older cows. The early calves gained at a higher rate than the late calves. The difference in three Hereford lines, which incidentally are the lines involved in this thesis, was small. A significant line difference did show up, however, because of the Angus line involved in the study.

Swiger (23), studying genetic and environmental influences on gain of beef cattle during various growth periods, found phenotypic correlations of .31 between birth weight and weaning weight, .26 between birth weight and feed lot gain, and .36 between birth weight and final weight. Weaning weight with feed lot gain was correlated .24 and with final weight .87. Feed lot gain and final weight was correlated .69.

Carter and Kincaid (5) found little relationship between grades and subsequent gains. For steers, there was a phenotypic correlation of -.07 between feeder grade at weaning and daily feed-lot gain. Correlations between

gains in a period and grade at the end of a period were moderate to high, however. Feeder grade with weight at six months showed a genetic correlation of .49 for steers. The genetic correlation of daily gain on feed with live grade at slaughter was .48; with carcass grade it was .84. Phenotypic correlations were similar, but generally smaller. These workers found a genetic correlation of .66 between feeder grade at weaning and live grade at slaughter, the phenotypic correlation being .36. Respective genotypic and phenotypic correlations between feeder grade and carcass grade were .65 and .16, and between slaughter grades and carcass grades .86 and .60. They also found a genetic correlation of .69 and a phenotypic correlation of .27 between weight at six months and feed lot gain, which they interpreted, if it would hold true generally, as meaning that selection made at weaning for heavier weights would result in improvement in performance in subsequent growth rates. As these latter correlations differed so much from those found by other workers, they concluded that environment made the difference. Conditions where Carter and Kincaid worked (Virginia), were more uniform the year round, meaning no interruption of growth as is found under range conditions, where correlations have been found to be low or negative.

In weight constant tests Nelms and Bogart (20)

found that for heifers there was a significant negative correlation between age on test and score at 800 pounds, and no significant correlation between score at 500 pounds and age on test, suggesting that better doing calves during the suckling period are not the better looking calves at 500 pounds. This could be attributed to type of growth, which is largely skeletal and muscular at this early age. These same calves that do well early have the ability to go ahead and do well later and look better at a heavier weight. With bulls, there was no significant correlation between scores at 500 pounds and 800 pounds, while there was with heifers. This was explained by the fact that heifers might look more mature at 500 pounds than do the bulls. Heifers probably started fattening at 500 pounds, under the regime of this particular study, since the correlation existed. A negative correlation between age on test and birth weight was found and would be expected as larger calves at birth reach weaning size earlier in life.

Shelby et al (22) were mainly concerned with heritability of economic characteristics in Record of Performance bulls. In their analysis of various traits, they found that differences between years were highly significant. Weaning weight at 180 days, weaning score, feed lot gain for a 196-day period and final weight were influenced greatly by year effects, ranging from 36% to 44% of

the total variation in these traits. Birth weight was only affected slightly by year effects, 11%. They found highly significant differences between lines within years for weaning weight, and significant differences for feed lot gain and final weight. Even though these line differences were significant, their actual effects accounted only for 7, 13, 9, 7, 11, and 19% of the variance in birth weight, weaning weight, feed lot gain, actual and adjusted final weight and feed efficiency respectively. So differences between lines were small compared to differences between years. Their conclusion, again considering heritability, was that final weight at 13 months would be the best criterion for selection, as the study indicated that weight at this age was enough different between sire groups and lines of breeding to make progress by selection for this character.

Knapp and Clark (15) concluded that the environmental influences on gains were feed consumption, temperature, and feeding and management practices. Score at weaning would be influenced by maternal influences (mothering ability), milk production of the dam, and range conditions. They explained negative relations between environmental influences of scores and gains by possibly a compensating increased gain in the feed lot for poor environmental conditions before weaning, and/or, since

hereditary influences are measured by sire variances, then within sire groups, the better milking cow may have a poorer heredity for gains from her and so make poorer gains in the feed lot. The calf from the poorer milker could get genes for better gains and do better in the feed lot. This all assumed a negative relationship between gains and milk production. The lack of correlation between scores and gains,both gross and genetic, could be of benefit to the breeder in that he could select for both conformation and rate of gain and make the progress he desired. Selecting for one would not influence the other. It would also mean that it would be possible to select within any type of animal, for greater rates of gain without affecting the type or conformation. These workers came to the conclusion, as many others did, that selection of feeder calves for rapid gain by visual appraisal is ineffective. The value lies only in the fact that feeder score indicates the slaughter grade that will be reached. A gross correlation of .0001 was found between score at weaning and gains in the feed lot. Genetic correlation amounted to .300, but the environmental correlation was -.304.

MacDonald and Bogart (17) studied the relationship between rate and efficiency of gain in breeding beef cattle, finding type score increased with an increase in

weight from 500 to 800 pounds body weight, but the coefficient of repeatability was only .39. Neither type score at 500 pounds nor type score at 800 pounds was significantly correlated with any of the production factors studied. There was a significant correlation between birth weight and rate of gain to 500 pounds, and also between birth weight and rate of gain from 500 to 800 pounds. Post-weaning rate of gain couldn't be accurately predicted from gains during the suckling period. They concluded that selection criteria for beef bulls and heifers can't be considered adequate unless both type and production factors are included in a selection index. Production factors were concluded to be of greater value to the commercial producer than carcass conformation, which is dependent to a high degree on plane of nutrition, an environmental, not a genetic, factor.

Genetic correlation between daily gain and type was found by Lehmann, et al (16) to be .007. Correlation between weaning weight and type was -.026. These correlations were interpreted to mean that growth and type are genetically independent. The phenotypic correlations were .42 and .39, indicating that weight, which was probably degree of finish, and body type were positively associated in the eyes of the grader. Genetic and phenotypic correlations between daily gain and weaning weight were

found to be .93 and .97 respectively.

Guilbert and Gregory (9) stated that even though size and conformation are not related to rate or economy of gain, "weight for age" has been a desirable selection point. Between two animals that have potentially equal mature size, the one that gains and matures more rapidly under similar environments is most often the more efficient because of the proportion of feed used for maintenance and for production.

Black and Knapp (1) found that weaning weight was negatively correlated with subsequent fatness and positively correlated (.66) with pounds of carcass per 100 pounds TDN. Also, average daily gain from birth to weaning and weaning to slaughter was negatively correlated, -.36, showing that animals growing at a greater rate on milk tend to gain more slowly afterwards. Correlation of weaning weight to percent fat in the carcass was -.62, and correlation between average daily gain and feeder grade was .42. Heavier steers at weaning put on the least fat and made the more economical gains, which is expected on the basis that milk is mostly a growing feed and not a fattening feed. Calves putting on a large gain from birth to weaning tend to grow with less fattening. These workers pointed out that variations in weaning weight, coupled with a constant slaughter weight, which was the case in

their study, means that the heavier animal at weaning has less time on a fattening ration and so would be penalized as far as carcass grade was concerned. Weaning at a constant weight and putting on a constant weight in the feed lot would make the mean weight of all animals the same, and the maintenance requirements, on the average, would be the same.

Yao et al (24) found that steers with heavier birth weight tended to have poorer slaughter grade, carcass grade, and dressing percent than steers with a lighter birth weight. Correlation of birth weight with slaughter grade was -.11, with carcass grade -.18, with dressing percent -.13, and with daily gain .19. The correlation of carcass grade with daily gain was .08 and with slaughter grade .70. Dressing percent was correlated with daily gain -.09, with slaughter grade .30, and with carcass grade .47. These workers concluded that live scores could be used to predict carcass grades and, to a lesser extent, dressing percent. Magee et al (19), studying factors affecting carcass grades in steers, found that gain had a larger effect than age, final weight, or area of loin eye on the carcass grade of steers, accounting for 11% of the variation in carcass grade. All the previous factors together accounted for 34% of the variation. Carcass grade was more highly associated with final weight, .52, than any of the other

variables.

Kidwell and McCormick (14) determined that in Herefords, carcass grade is not associated with weight (.33) as compared to a high association in Holsteins (.80). This they regarded as due to differences in fatness making the association in Holsteins, whereas in the Herefords all were well finished; therefore conformation was more important in determining carcass grade. They also found that dressing percentage is highly associated with grade in Holsteins (.69), but not in Herefords (-.01), again giving the conclusion that fatness determines carcass grade in Holsteins, but not in Herefords. Shrinkage was not found to be associated with grade in either Holsteins (-.07), or Herefords (.04), meaning that fat cover did not affect shrinkage. Kidwell et al (13) again studied relationships in production and carcass characteristics and determined that there was a significant correlation (.89) between score and percent fat in the 9-10-11 rib, indicating that fatness is the most important factor in determining grade. Seventy-nine percent of the variation in carcass score was accounted for by variation in fat. Correlation of carcass score with dressing percent and percent wholesale cuts showed again that correlations were due to the fat content. Production-wise, there was little relation between feeder grade and later rate and

economy of gain. Feeder grade was associated positively with carcass grade, dressing percent, and percent fat in the 9-10-11 rib. These workers found no relation between slaughter score and rate and economy of gain, but a fairly high relation between slaughter grade and carcass score, dressing percent, and percent bone, muscle, and fat in the 9-10-11 rib. Feeder measures had little relation to either production or carcass traits. Higher grading carcasses yielded more fat, less bone and muscle, and a high percent of loin, rib, and plate, and a low percent of round and chuck. Furthermore, there was no association between tenderness scores and fatness, average daily gain, or any other preference measures.

Durham and Knox (8) found no correlation between weaning grade and carcass grade. There was a low association between yearling grade and carcass grade. Their studies of correlations at different stages of growth further showed that grade at the beginning of a period tended to be negatively associated or not at all with subsequent gains. Gain during the fattening period was associated with the subsequent grade. Lack of correlation between calf grade and carcass grade was explained by differences in grading standards. Condition hardly enters into feeder grading, but carcass grade is almost all determined by condition. Because of this lack of correlation between

good scoring calves and subsequent good grading carcasses, these workers suggested that the breeder ought to look for cow productivity and feed lot efficiency rather than perfectly formed calves, as the latter evidently makes the high weaning score. They elaborated on this by noting that gains on feed in their study were associated to a greater degree with succeeding grades than with previous ones. Cattle that graded high at the start of the feed test were not always fast gainers, but fast gainers tended to grade high at the end of the feed test.

Average daily gain had a positive correlation with carcass grade and dressing percent in a study made by Cook et al (6). They found a significant negative relationship between feed efficiency and dressing percent, which they interpreted as meaning that animals with a higher dressing percent have more fat, and so had utilized more feed in putting on weight than steers with more of their weight in muscle. For two groups of steers correlations between slaughter grade and carcass grade were high, being .69 and .71. Dressing percent was correlated with slaughter grade to a significant extent, .25 and .45 respectively. The conclusion was that the visible slaughter grade was a good indication of carcass qualities and that a carcass with a high dressing percent would have a higher carcass grade.

Kidwell (12) found with steer calves 10-16 months

of age, which had been fed 180-240 days, that dressing percent was correlated with weight, .578, with slaughter grade .652 and with carcass grade .714. Other correlations led Kidwell to believe that much of the observed correlation among various body measures arises from their relation to general size, which is also true for relations between measurements and carcass traits.

Branaman et al (2) studied the relation of finish in cattle to production and meat flavors. They found that the percentage of fat in the most highly finished cattle was about 2.5 times as large as that in cattle having the lowest degree of finish. With increasing finish, steers and heifers as slaughter cattle graded higher. As the cattle became fatter, there was a marked tendency for dressing percent to increase. There was also a marked increase in edible meat to bone as the fat content increased. An increase in firmness of lean and marbling of rib eye was associated with an increase in finish of both steers and heifers. An increase in intramuscular fat, which accompanied the increases in firmness and marbling, made a large contribution to them. Flavor score of lean improved with an increase in fatness. Tenderness, however, appeared to decrease on the basis of palatability, but not consistently on the basis of mechanical tests. This was interpreted as meaning that tenderness was not definitely affected

by increasing the degree of finish, but that the meat was tender to start with and remained so throughout the experiment. According to Mackintosh et al (18), increased finish apparently rendered meat more tender, as concluded by tenderness measurements taken by shear tests, palatability committees, and analyses of tissue content of the flesh. Older cattle had higher shear and collagen nitrogen factors, and tenderness was lower, even though palatability was only slightly lower. The change in tenderness seemed to be related to grade of carcass and marbling in the muscle. Cover et al (7) found a correlation of .784 between estimated fat in the carcass and marbling.

Kennick and England (11) described a method of estimating percentage of protein and fat in the edible portion of steer carcasses. They described the need of finding how much fat and lean is present in the carcass, as being based on consumer preference for more lean and less fat, and the fact that the meat industry loses money from excess fat. An objective to keep in mind, then, would be the production of carcasses carrying a large amount of lean. From a series of core samples taken from rib cuts, it was found that carcass weight influenced the weight of the fat in the probes, shown by a correlation of .64. Prediction equations were derived to predict fat and protein content of the boneless portion of the 9-10-11 rib cut,

which could in turn be used to determine the relative degree of fatness or leanness of steer carcasses. Then these predicted values are transformed to percent protein and fat in the edible portion of steer carcasses by using prediction equations derived from previous studies and described by Kennick (10).

METHODS AND MATERIALS

The data analyzed for use in this thesis were obtained from the Eastern Oregon Branch Experiment Station, Union, superintended by J. A. B. McArthur. The animals involved in this study were the 1958, 1959, and 1960 calf crops from the commercial Hereford herd maintained at the station under the range conditions typical of Eastern Oregon. The entire cow herd is yearly separated into four breeding groups, each of which is run with a purebred Hereford bull of different lineage. Three sires were obtained from the central station at Corvallis and were representative of the Lionheart, Prince, and David lines. The fourth sire line, the Union, originated from an Eastern Oregon herd. The cow herd also originated in 1948 from this same herd, and so there is some relationship to this sire line. Cows from the entire herd were assigned at random yearly to the four breeding herds. In this study a different bull was used yearly from the Lionheart, Prince, and David lines, with the same Union bull being used all three years. The three sire lines from the central station are performance tested before being selected for use at the Union station or any other point where they are sent. The performance records include data on suckling gain, feed lot rate of gain, feed efficiency, and score.

In the three years 79 steer calves were used for

this study. In 1958, 24 animals were available, 26 in 1959 and 29 in 1960. The numbers of animals in each sire line were unequal yearly.

The bulk of the calves were dropped in March at Union, and the management procedure involved castration and dehorning at birth. Records on the calves were started at this time when birth weights and dates were recorded. All calves were weaned at a constant date, around the last of October or first part of November. Weaning weights were obtained. A varying period of time elapsed before the animals to be feed-tested were actually put on feed. They were again weighed and scored for type and condition. The steers involved in this study were group-fed in pens of 12. A non-pelleted concentrate ration was fed, composed of 50% wheat, 40% barley, 5% cottonseed meal, and 5% linseed oil meal. On top of this, hay was fed ad libitum. The proceedure is to feed the animals until August, when they are marketed in Portland, meaning that all animals come off feed on the same date. Weights off test were obtained. At Portland, cold and warm carcass weights were obtained (warm weights are used in this study). Furthermore, marbling and conformation scores and USDA grades on the carcasses were obtained. Core samples were obtained on the calves born in 1958 and 1959 to arrive at the estimated percent fat in the carcass. Loin eye tracings were made

on the calves born in 1960, and percent fat calculated from measurements on the total loin eye area, miscellaneous lean, and total lean according to the formula: % fat = 9.44 + .0295 x % fat area + .019 x warm carcass weight (10). As information on loin eye area was not available for the calves born in 1958, no analysis was run on loin eye data as such. From the data obtained, suckling gains, feed lot rates of gain, and dressing percentages were also calculated. The ages of the dams were available and were included in the regression analysis to be described later.

Eight dependent variables were analyzed factorially to determine the influence of line of sire and year. These variables were: weight off feed, daily gain, carcass weight, USDA grade, dressing percentage, marbling score, conformation score, and percent fat. Least significant differences were computed for years and lines on these eight variables.

Analyses by least squares were also run on the same eight variables. Models were set up to determine the effect of several independent variables on these eight as follows:

Weight off feed - dependent variable

Independent Variables

1	year effect	6	weaning age
2	line effect	7	suckling gain
3	age of dam	8	weight on feed
4	birth date	9	type score
5	birth weight	10	condition score

Daily Gain - dependent variable

Independent variables - same as above.

Carcass weight - dependent variable

Independent variables - same as for weight off feed plus the variable daily gain.

USDA grade - dependent variable

Independent variables - same as for weight off feed plus the variables daily gain and carcass weight.

Dressing percentage - dependent variable

Independent variables - same as for weight off feed plus the variables: daily gain, carcass weight, marbling, carcass conformation, and percent fat.

Marbling score - dependent variable

Independent variables - same as for weight off feed plus the variables: daily gain, carcass weight, carcass conformation score, and percent fat.

Carcass conformation score - dependent variable

Independent variables - same as for weight off feed plus the variables: daily gain, carcass weight, marbling score, and percent fat.

Percent fat - dependent variable

Independent variables - same as for weight off

feed plus the variables: daily gain, carcass weight, marbling, and carcass conformation score.

RESULTS

The means of the eight dependent variables by years and lines are shown in Table 1 (pp 26, 27). The mean squares which were obtained from the factorial analysis of line, year, and interaction effects on the variables in question are shown in Table 2 (p. 28). The line, year, and interaction mean squares are the adjusted mean squares, which take into account unequal sample sizes. The table shows where significant differences appeared between lines and years and where significant interactions appeared between lines and years.

Line differences were highly significant for USDA grade, dressing percent, and marbling score. Significant line differences were found for daily gain, carcass weight, and carcass conformation (Table 2). There were no significant line differences for weight off feed and percent fat.

Year differences were highly significant for weight off feed, daily gain, carcass weight, USDA grade, and carcass conformation score. A significant year difference was found for percent fat. Dressing percent and marbling score showed no significant differences between years (Table 2).

TABLE 1

MEANS OF DEPENDENT VARIABLES BY LINES AND YEARS

	David			Prince			Lionheart		
	1958	1959	1960	1958	1959	1960	1958	1959	1960
Weight off Feed	999.33	1065.00	1031.11	917.00	1046.50	970.50	920.00	1050.00	1071.25
Daily Gain	2.13	2.29	2.38	1.85	2.26	2.20	2.10	2.27	2.42
Carcass Weight	579.50	630.70	604.77	550.50	611.75	569.40	525.33	631.00	632.50
USDA Grade	15.17	14.30	14.22	16.50	14.00	16.00	14.83	15.00	14.88
Dressing Percentage	57.85	59.17	58.59	60.00	58.44	58.64	58.08	60.08	58.91
Marbling Score	12.33	9.30	10.00	11.50	10.12	13.20	10.66	12.00	14.12
Carcass Conformation Score	15.67	15.20	15.67	16.00	15.62	16.20	16.50	15.75	15.62
Percent Fat	33.73	32.20	32.12	33.30	31.96	30.60	32.85	32.95	32.81
Number of Steers	6	10	9	2	8	5	6	4	8

con't. p. 28

(Table 1, con't.)

(Means of Dependent Variables by Lines and Years)

	Union		
	1958	1959	1960
Weight off Feed	957.80	913.75	1055.71
Daily Gain	1.98	2.04	2.37
Carcass Weight	555.00	512.75	600.28
USDA Grade	13.90	13.50	14.14
Dressing Percentage	57.91	56.08	56.80
Marbling Score	8.90	9.75	9.28
Carcass Conform-ation Score	15.90	14.00	15.57
Percent Fat	32.71	30.02	31.36
Number of Steers	10	4	7

TABLE 2

FACTORIAL ANALYSIS OF LINES, YEARS, AND INTERACTIONS

		MEAN SQUARES			
Source of Variation	D.F.	Weight off Feed	Daily Gain	Carcass Weight	USDA Grade
Lines	3	22782.72	.2184*	14188.56*	14.4889**
Years	2	80558.31**	1.0846**	29206.41**	8.4000**
Lines x Years	6	30800.19**	.8842	14709.40**	4.3889**
Error	67	8929.78	.0792	3855.40	1.1560
Total	78				

	MEAN SQUARES			
Source of Variation	Dressing Percent	Marbling Score	Carcass Conformation Score	Percent Fat
Lines	26.13**	49.4222**	4.2778*	14.42
Years	.65	18.4333	8.1250**	25.98*
Lines x Years	14.10**	20.5888**	2.1028	6.21
Error	2.11	6.2223	1.4679	6.03

* Significant at the 5% level
** Significant at the 1% level

Interactions between lines and years were highly significant for weight off feed, carcass weight, USDA grade, dressing percent, and marbling score. No significant interactions for daily gain, carcass conformation score, and percent fat were noted (Table 2).

Adjusted line and year means, from which least significant differences were computed (LSD's), are shown in Table 3 (p. 30). Which line or lines and year or years accounted for the significance noted in Table 2 are apparent on inspection by use of the LSD. Differences are also found in some cases by use of the LSD, especially between high and low lines, even though the data in Table 2 do not show a significant difference for a particular line or year for the variable being considered. Statistically, a significant difference will not be claimed in these cases. Each line for each variable can be evaluated from the means shown in Table 2 to determine whether or not significant differences existed. In other words, the order of performance in each line for each trait can be seen.

The calves sired by the bulls of the David line were heavier than those of the Lionheart, Prince, and Union lines, in that order. Weights of the 1960 animals were significantly greater than those of the 1958 animals. Likewise, the animals in 1959 were significantly heavier than those in 1958. There was no significant difference between

TABLE 3

ADJUSTED LINE AND YEAR MEANS

	LINE				YEAR		
	David	Prince	Lionheart	Union	1958	1959	1960
Weight off Feed	1031.80	977.80	1013.70	957.80	948.50	1018.80	1032.00
Daily Gain	2.264	2.102	2.263	2.133	2.015	2.215	2.341
Carcass Weight	605.0	577.2	596.3	556.0	552.6	596.6	601.8
USDA Grade	14.6	15.5	14.9	13.8	15.1	14.2	14.8
Dressing Percent	58.54	59.03	58.69	56.93	58.21	58.44	58.24
Marbling Score	10.53	11.60	12.27	9.30	10.8	10.3	11.6
Carcass Conformation Score	15.5	15.9	16.0	15.2	16.0	15.2	15.8
Percent Fat	32.68	31.95	32.87	31.36	33.15	31.78	31.72
Number of Steers	25	15	18	21	24	26	29

the 1960 and 1959 animals for this variable.

The David line had a greater daily gain, followed by the Lionheart, Union, and Prince lines in that order. The biggest difference for this trait existed between the two top lines and the bottom two lines. The rates of gain of steers in 1960 were higher than those in 1959, a significant difference being found. They were even higher than the 1958 animals, where a highly significant difference was noted. The rates of gain of the 1959 animals were significantly greater than those of the 1958 animals.

The calves sired by the David line had heavier carcass weights than the calves sired by bulls of the other lines. They were significantly heavier than those sired by bulls of the Union line, but, although heavier, they were not significantly heavier than calves sired by bulls of the Lionheart or Prince line. The Lionheart-sired calves had significantly higher carcass weights than calves sired by bulls of the Union line. Carcass weights for all animals in 1960 and 1959, though not significantly different, were significantly heavier than carcasses in 1958.

The Prince, Lionheart, David, and Union-sired calves ranked in that order for USDA grade. There was a highly significant difference between all the first three lines and the Union line. No significant difference between the Prince and Lionheart calves or between the Lionheart and

David lines was noted, though there was between calves of the Prince and David lines. The animals in 1958 had the highest USDA grade, with 1960 and 1959 following in that order. The difference between grades in 1958 and 1959 was highly significant, and between 1960 and 1959, significant. No significant difference existed between grades in 1958 and 1960.

For dressing percent, the lines of sires ranked the same as for USDA grade. Again, the first three lines showed a highly significant difference when compared with the Union line. No significant differences existed among the first three lines, nor between years for USDA grade.

The Lionheart-sired calves had the highest marbling score, followed by those of the Prince, David, and Union lines in that order. Highly significant differences existed between the Lionheart and David, Lionheart and Union, and the Prince and Union calves. No significant differences were found between the Lionheart and Prince, the Prince and David, or David and Union lines. Year differences were not significant.

The calves sired by bulls of the Lionheart line had the best carcass conformation scores, followed by those sired by bulls of the Prince, David, and Union lines. The only significant differences existed between the Lionheart and Union and the Prince and Union lines. Between the

years 1958 and 1960 no significant difference was found for this variable, but the scores were significantly higher in 1958 than in 1959.

The calves sired by bulls of the Lionheart line had the highest percent fat in the carcasses, followed by those sired by bulls of the David, Prince, and Union lines. The animals in 1958 were significantly higher in percent fat than the animals in 1959 and 1960. Between 1959 and 1960 no significant difference was found.

In the multiple regression analysis, the only independent variable showing any significant effect (other than line and year effects) on weight off feed was weight on feed. All the independent variables concerned, which were listed in the model, accounted for 57.52 percent of the variation in weight off feed. The regression coefficient for weight on feed was 1.87, meaning that for every pound increase in weight on feed, there was an increase of 1.87 pounds in weight off feed.

The analysis on daily gain showed no significant effect from any of the independent variables, with the exception of lines and years. The coefficient of determination showed that the model accounted for 33.77 percent of the variation in daily gain.

Only one independent variable, other than lines and years, showed a significant effect on carcass weight. This

was weight on feed, which was highly significant. The regression coefficient of carcass weight on weight on feed was .64, showing that for each pound of increase in weight on feed, there was an increase in carcass weight of .64 pound. Like the dependent variable of weight off feed, this means only that the animals that are heavier initially are heavier when coming off test and yield heavier carcasses. Ninety-seven percent of the variation in carcass weight was accounted for by the model used in this analysis. None of the independent variables except years and lines showed a significant effect in the multiple regression analysis of USDA grade, and only 32.60 percent of the variation in USDA grade was accounted for in the model.

Five variables, in addition to lines and years, affected dressing percentage greatly. They were birth weight, carcass conformation score, weight on feed, daily gain, and carcass weight. The regression coefficients for birth weight and carcass conformation scores on dressing percent were .00940 and .056 respectively. The regression coefficients for weight on feed, daily gain, and carcass weight were -.06, -1.62, and 1.03 respectively. All independent variables used in the model accounted for 98.77 percent of the variation in dressing percent.

None of the independent variables except lines showed significant effects on marbling score. Only 35.59 percent

of the variation was accounted for by the model.

The analysis on carcass conformation score showed that type score, with a regression coefficient of -.58, condition score, with a regression coefficient of .72, and percent fat, with a regression coefficient of .19 had significant effects. Forty-nine percent of the variation in carcass score was accounted for by the model.

Percent fat was significantly affected only by carcass conformation, years, and lines. The regression coefficient was .45, meaning that the higher scoring carcasses carried more fat. Seventy percent of the variation was accounted for by the model.

Correlations are shown in Tables 4, 5, and 6. Correlations among the independent variables involved in the analysis are shown in Table 4 (p. 36), with those showing any significance indicated by an asterisk. In this table all correlations showing any significance at all were highly significant. Correlations among the dependent variables are shown in Table 5 (p. 37). Correlations between the dependent and independent variables are shown in Table 6 (p. 38).

TABLE 4

CORRELATION COEFFICIENTS INVOLVING INDEPENDENT VARIABLES

	Birth Date	Birth Weight	Weaning Age	Suckling Gain	Weight on Feed	Type Score	Condition Score	Percent off Feed
Age of Dam	-.10	-.07	.12	.49**	.39**	-.16	-.08	.08
Birth Date		-.06	-.91**	-.15	-.56**	.35**	.44**	-.54**
Birth Weight			.09	.06	.22	.09	.19	.20
Weaning Age				.15	.50**	-.15	-.21	.43**
Suckling Gain					.86**	-.38**	-.34**	.44**
Weight on Feed						-.47**	-.51**	.66**
Type Score							.84**	-.42**
Condition Score								-.45**

* Significant at the 5% level
** Significant at the 1% level

TABLE 5

CORRELATION COEFFICIENTS INVOLVING DEPENDENT VARIABLES

	Daily Gain	Carcass Weight	USDA Grade	Dressing Percent	Marbling Score	Carcass Conformation Score	Percent Fat
Weight off Feed	.80**	.97**	.09	.44**	.13	.32**	.59**
Daily Gain		.74**	.08	.18	.20	.32**	.33**
Carcass Weight			.14	.63**	.16	.30**	.60**
USDA Grade				.25*	.66**	.49**	.18
Dressing Percent					.18	.11	.37**
Marbling Score						.32**	.15
Carcass Conformation Score							.49**

* Significant at the 5% level
** Significant at the 1% level

TABLE 6

CORRELATION COEFFICIENTS OF DEPENDENT WITH INDEPENDENT VARIABLES

Dependent Variables	Independent Variables							
	Age of Dam	Birth Date	Birth Weight	Weaning Age	Suckling Gain	Weight On Feed	Type Score	Condition Score
Weight Off Feed	.08	-.54**	.20	.43**	.44**	.66**	-.42**	-.45**
Daily Gain	-.20	-.32**	.11	.19	-.11	.12	-.25*	-.26*
Carcass Weight	.13	-.52**	.16	.42**	.50**	.69**	-.44**	-.48**
USDA Grade	.19	.17	-.20	-.16	.17	.06	-.04	-.04
Dressing Percent	.24*	-.25*	-.04	.21	.47**	.50**	-.30**	-.40**
Marbling Score	-.06	.14	-.08	-.18	.06	.02	-.04	-.09
Carcass Conformation Score	-.04	.004	-.06	.10	.13	.11	-.04	.07
Percent Fat	.27*	-.28*	-.006	.41**	.46**	.48**	-.15	-.15

* Significant at the 5% level
** Significant at the 1% level

DISCUSSION

Comparison of the performance of the three lines show that, in most cases, the Union line was not equal in performance to the other three lines. The differences found in the traits were to a large extent, though not entirely, accounted for by the poor performance of this line. It should be brought out, however, that the bull used from this line was somewhat related to the cows in the commercial herd, a factor which could put the Union line at a disadvantage for comparative purposes. On an unrelated herd of cows, its performance might be better. Besides, over a three-year period, the same Union bull was used. It may be that this animal was not as good as he was considered to be before he was used. A different bull was used from the Prince, Lionheart, and David lines each year, each being used as a consequence of his own records.

The David bulls considered in this study sired animals superior in weight off feed, daily gain, and carcass weight. The calves were not scored as high as those sired by bulls of the Prince line in USDA grade and not significantly different from the top two lines in dressing percent. They ranked significantly lower than calves of the Lionheart line in marbling and were lower, but not significantly, in carcass conformation score than calves sired by bulls of the top two lines, carrying about the same percent fat as the

calves sired by the bulls of the Lionheart and Prince lines. The calves sired by the bull of the Union line had the lowest percent fat in the carcass.

The Lionheart calves were slightly, though not significantly, lower than the David calves in weights off feed, daily gain, and carcass weight. They were also slightly lower than the calves of the Prince line in USDA grade and in dressing percent. The Lionheart calves were highest in marbling and carcass conformation scores, also carrying the highest percent fat of all the calves.

Prince-sired calves were lighter coming off feed than the Davids and Lionhearts. They showed the lowest daily gain of any of them. Their carcasses were slightly lighter than carcasses of the Davids and Lionhearts. The Prince line excelled in USDA grade and dressing percent. Calves from sires of the Prince line were slightly lower in marbling than those of the Lionheart line. They were significantly higher in marbling and carcass conformation score than calves sired by the Union bull.

The calves sired by the Union bull were the lowest in all traits except daily gain, in which they were slightly above the calves sired by bulls of the Prince line.

The fact that the David bulls sired calves that were heavier and showed better gain should offset some of the criticism this line has received in the closed herd as far

as conformation is concerned. Performance is of more value to the commercial producer than conformation (17). Conformation was better in the Lionheart calves, which was not surprising, as this quality is noted in the line at the Central Station. It can be said that the Lionheart line has a tendency to carry too much fat; however, the lack of correlation between marbling and fat in the study, contrary to the findings of other studies (2, 7), can be interpreted as meaning that none of the calves sired by any of the lines were excessive in fat. Carried on to a heavier weight, with increasing age, however, the Lionhearts may show excess fat to a greater extent. The amount of fleshing on the Lionheart cows in the closed herd at the Central Station has been noted. The mean marbling score for all the animals involved in this study was 10.696, with a standard deviation of 2.87. These figures can be compared with the range of marbling scores in Table 7 (p. 42), which are used when marbling is estimated.

TABLE 7

MARBLING SCORE CLASSIFICATIONS

	Low	Average	High
Extreme abundant	32	33	34
Very abundant	29	30	31
Abundant	26	27	28
Modestly abundant	23	24	25
Slightly abundant	20	21	22
Moderate	17	18	19
Modest	14	15	16
Small	11	12	13
Slight	8	9	10
Traces	5	6	7
Practically devoid	2	3	4
Devoid		1	

The mean of 10.696 lies between the slight and small classification. This appears to be a low marbling score, but the classification may be used by the grader on the basis of what older, more highly finished animals would score. Younger animals, as in this study, may be at a disadvantage when forced to fit into this classification. The mean USDA grade for the 79 animals was 14.52, with a standard deviation of 1.21 which falls midway between the average and high good grade, as seen in Table 8 (p. 43). The mean carcass conformation score was 15.64 with a standard deviation of 1.23. This falls between the good and choice grades, according to the same system of classification.

TABLE 8

USDA GRADE AND CARCASS CONFORMATION CLASSIFICATIONS

	low	average	high
Prime	19	20	21
Choice	16	17	18
Good	13	14	15
Standard	10	11	12
Utility	7	8	9
Cutter	4	5	6
Canner	1	2	3

Had the animals carried more fat, they undoubtedly would have graded into the choice range, a supposition that tallies with conclusions drawn by other workers (2, 13, 14).

It has been shown (2, 18) that tenderness of beef increases in some instances and decreases in others, though not consistently, with increased finish. This characteristic undoubtedly is associated with age. Consequently, if the animals in this study had been subjected to tenderness tests on the cuts of beef, the results probably would have shown that the meat was sufficiently tender according to age and that the amount of fat carried was sufficient for good flavor. Although these tests were not conducted, on the basis of previous work, it appears that the grading, if used as the criterion for consumer preference, would not be realistic when applied to these younger animals.

Certainly, excess fat is not advantageous to the producer, who must invest more for this stage of development than for muscular growth.

It may be worth while to consider again the calves which carried more fat. The Lionheart line tends to have too much of its carcass weight in fat, whereas the David and Union animals had carcasses which were economically of greater value. One should be careful, however, in being too explicit concerning the Union line, because of the otherwise poor performance it made, again qualifying this statement by reservations made earlier concerning possible reasons for their performance.

The calves sired by the Prince bulls made lower daily gains, which again were comparable to results obtained at the Central Station. When all the traits are considered, it appears that the David line was generally superior insofar as production traits were concerned even though the carcasses of animals sired by the David bulls graded lower.

Year differences were noted for weight off feed. As may be seen in Table 3, the animals became increasingly heavier from 1958 through 1960, and daily gain and carcass weight improved in the same manner. These improvements indicate that the environment improved, with consequent effects on the calves from birth to the time the carcasses were evaluated. Any improvement in range and pasture

conditions will, through its effect on the dams, get the calves off to a good start and a higher weight on feed, and subsequently to a heavier carcass. The fact that year differences for USDA grade and carcass conformation did not follow this same trend, 1958 being the year both traits were scored higher, indicates that the heavier steers in 1960 grew with less fattening (1). Probably, in scoring carcass conformation, the grader was influenced by the USDA grade.

Percent fat also was highest in 1958 and lowest in 1960.

As for interactions noted between lines and years, it can be assumed that the steers differed genetically, and the environment differed from year to year. Feeding regimes and management were as constant as could be provided for under the combination of range and feed lot conditions, but environment over all could not, of course, be controlled. The response, then, of the genetic potential of the sire lines to differing environmental conditions, gave rise to the interactions noted for certain variables.

Weight on feed had a significant effect on weight off feed, a natural consequence of a time-constant experiment. The mean weight of the animals going on feed was 410 pounds, with a standard deviation of 63 pounds. The mean weight off feed was 1011 pounds, with a standard deviation of 103

pounds. The mean age at weaning was 217 days, with a standard deviation of 13 days, and the time in the feed lot was 9 months, making the animals about 16 months old when coming off feed. Weight on feed also showed a significant result in carcass weight. The animals that were heavier on feed were, of course, older and, when coming off test, weighed 1.87 pounds heavier for every pound of increase in weight on feed. The difference in regressions of live weight and carcass weight on weight on feed can be accounted for by fill, offal, and shrinkage. The significant effect of weight on feed does show that the animals had the genetic capacity to grow well to a heavy final weight under the feeding regime.

Birth weight, weight on feed, daily gain, carcass weight, and carcass conformation had significant effects on dressing percent. The regression coefficients of .0094, -.064, -1.62, and .10 and .056 indicate that calves that were heavier at birth but lighter when going on feed, gained at a slower rate in the feed lot, had a heavier carcass, and were scored higher in conformation as well as having a higher dressing percent. Ninety-eight percent of the variation in dressing percent was accounted for by the model. It may be that the model is confounded by too many variables involving weights. It seems logical that heavier animals at slaughter would have a higher dressing

percent, with a lower proportion of the animal's weight accounted for by waste. Animals having better conformation, even if the score was influenced by finish, would also logically dress out a heavier carcass. The heavier calves at birth had a higher dressing percent, which could also mean more carcass in proportion to total weight. However, the effect of weight on feed was negative, as was the effect of daily gain. The lighter animals going on feed were the same animals with a heavier birth weight, and they did not compensate for poor suckling gains when put on test. Perhaps the results may be accounted for by the fact that in the regression analysis, each regression coefficient and effect is calculated with every other effect held constant, so that an individual effect can give an unexpected result. Again, this could be a result of putting too many variables concerning weights into this particular model.

That the finish of the animals affected the carcass conformation score is indicated by the significant effect that percent fat had on the score. Type and condition scores also had a significant effect on carcass conformation score. Scores on the live animal are a good indication of how the carcass will score, but finish determines much of the score (14).

The correlation study showed results involving many

significant associations between traits. Those which involved correlations between the independent variables are as follows: age of dam was found to be associated with suckling gain (.49), which shows that the milk production of the cow is the important factor in suckling gain and that her age helps to determine her milk production for any given lactation. Similarly, the correlation with weight on feed (.39) is explained in the same manner, this weight being a function of the gains from birth made on the lactating cows. The mean age of the cows in this study was 5.9 years, with a standard deviation of 2.94 years. Most of the cows undoubtedly had yet to reach their peak in lactation, a conclusion in agreement with other studies (3). The negative correlation (-.91) between birth date and weaning age can be explained by the fact that the calves were weaned at a constant date, rather than by age or weight. Calves born later would be weaned at a younger age than those born earlier. A negative correlation (-.56) also existed between birth date and weight on feed, a circumstance which can also be explained as the previous correlation was, taking into consideration that these younger calves will weigh less when going on test. Positive correlations of .35 and .44 between birth date and type or condition score show that older calves were scored lower than younger calves, an

indication that the scoring favored small-type calves and that both type and condition were considered as one. Birth date and weight off feed were correlated negatively (-.54). This correlation was a result of putting the steers on feed and taking them off at constant dates so that the younger calves were lighter when taken off feed.

Weaning age was positively correlated with weight on feed and weight off feed, .50 and .43 respectively, also an indication that the older calves weighed more at both times.

A correlation of .86 between suckling gain and weight on feed was found. The inherent ability of the calf to grow, coupled with its dam's milk production, determined how much it would weigh when put in the feed lot. Most of the gain of the calves is determined by the milk production of the cow. A correlation of .44 of suckling gain with weight off feed indicates that the same calves that showed early growth carried this potential to the feed lot and grew rapidly there also. Type and condition scores were negatively associated with suckling gains. Evidently the scoring favored smaller calves instead of those that had the growth potential. The better gainers probably looked ungainly at a younger age, with a large part of their growth being skeletal and muscular (20). This conclusion is in line with the correlations found between

birth date and scores.

Weight on feed was also negatively associated with type and condition scores, (-.47 and -.51). The conclusions concerning these variables are the same as above. A positive correlation of .66 between weights on and off feed was found, with steers having more weight at the start of the feed test finishing at a heavier weight also.

Type and condition scores were highly correlated, indicating either that a real relationship existed between the two variables or that the two were considered as one in the scoring. At weaning, the calves would not carry much condition anyhow, so most of the higher scores would mean better conformation (8). The negative correlation of -.42 between type score and weight off feed again shows that the heavier calves were not favored in the scoring. Condition score with weight off feed also was negatively correlated, -.45, with the heavier calves seemingly having the lower condition. The calves scoring lower made good growth in the feed lot.

The correlations between the dependent variables were all positive. Weight off feed was highly associated with daily gain and carcass weight, (.80 and .97). These variables are intimately related, and high correlations are expected (23). Weight off feed with dressing percent was correlated .44, the heavier animals dressing out the

the most carcass in relation to live weight and undoubtedly having the most finish (2). A correlation of .32 was found between weight off feed and carcass conformation score, showing that the heavier animals did have better carcasses, contrary to the live animal scores for type and condition. Weight off feed and percent fat were correlated .59, showing that the heavier animals carried more finish. This conclusion could be expected, because the heavier animals in this study were older, and, as they became older, a higher proportion of their feed intake went toward putting on fat. The correlation between daily gain and carcass weight was .74, the better gainers yielding the heaviest carcasses. The better gainers scored better in the carcass, as seen by the correlation of .32 between daily gain and carcass conformation score. This result indicates that there can be an association between desirable performance and desirable conformation, though the statement has to be qualified on the basis of conformation score being influenced by the finish of the animal. The correlation of .30 between carcass weight and carcass conformation shows the same relationship and can be explained in the same way. Carcass weight and dressing percent were correlated, .63, and a correlation of .60 was found between carcass weight and percent fat in the carcass. The animals weighing more dressed out with less wastage

and had a higher finish than the smaller, poorly thriving animals. These scores show that the older, heavier animals had reached a stage where muscular growth was decreasing in proportion to fat (12, 2). A high USDA grade was also associated with a high dressing percent, .25, a high marbling score, .66, and a high carcass conformation score, .49, but not with percent fat. So even though USDA grade increased with marbling, there wasn't the excessive fat in these animals that might be expected, and conformation of the carcass was given considerable weight in grading the carcass. The correlation of .32 between marbling score and carcass conformation score and the lack of a significant correlation between marbling and percent fat indicates the same thing. Otherwise, if the animals carried more finish, one would expect a correlation between marbling and percent fat (7). So even though the fat content was greater in the carcasses that scored higher, none of the animals was overfleshed. The same conclusion can be reached regarding the correlation of .37 between dressing percent and percent fat.

The correlations between the dependent and independent variables are given in Table 6. The negative correlation,-.54, between weight off feed and birth date shows only that calves born earlier were heavier coming off feed in this date-constant management procedure. Similarly,

the positive association of .44 between weight off feed and weaning age is noted. Weight off feed and suckling gain were correlated, .44, showing, as before, that calves getting a good start from the dams and having the genetic potential to gain well, carried these through the feeding period (20). Weights on and off feed were also correlated , .66. Weight off feed was negatively associated with type and condition score at weaning, again indicating that scoring discriminated against the larger animals.

The negative correlation, -32, between daily gain and birth date showed that the older calves were better gainers in the feed lot, having had a chance to develop to the point where they could do well when placed on feed. Negative correlations between type and condition scores and daily gain, -.25 and -.26, showed that older calves, which had better gains in the feed lot, were not favored for type and did not appear to have as high a condition at weaning.

The lack of correlation between type or condition score with USDA grade conflicts with conclusions reached by Kidwell et al (14), but agrees with those reached by Durham and Knox (8), an indication that, in the present study, a different system was used when the respective scores and grades were placed on the animals and carcasses.

A correlation of .24 between dressing percent and age of dam was found. As the cows became older, their milk production increased, and, consequently, their calves were heavier at weaning, as may seen by the correlations between suckling gain and weight on feed. These same calves produced heavier carcasses, with higher finish and less wastage. The correlation of -.25 between dressing percent and birth date shows that the older calves also had heavier carcasses. A correlation of .47 between dressing percent and suckling gain was found, while weight on feed and dressing percent correlated .50. Both these correlations indicate the same relationship as above. Negative correlations of -.30 and -.40 between dressing percent and type score or condition score appears again to warrant the conclusion that less growthy calves were scored higher.

The correlation between the scores for type and condition and production characteristics results in the same conclusion that is often reached (5, 8, 9, 13, 15, 17, 20), i.e. that the scoring may favor a smaller, poorer-gaining animal that produces a less desirable carcass. Studies have shown both a lack of correlation and a negative correlation between scores and performance. The fact that negative correlations existed in the present study accentuates the desirability of testing an animal for its performance rather than relying on scores, which, being

subjective, can be misleading.

The result of percent fat being associated positively, .27, with age of dam and negatively, -.28, with birth date was similar to that existing between dressing percent and these two variables. Percent fat and weaning age were correlated .42, the older calves having stored more fat by the end of the feeding period. A correlation of .46 between percent fat and suckling gain again indicates that the more rapid gainers in early life had a greater chance to put on more fat later. That weight on feed and percent fat were correlated .48 can be similarly explained (2).

SUMMARY

Analysis of production and carcass characteristics of seventy-nine steer calves was conducted over a three-year period from 1958 to 1960. The calves were out of the commercial cow herd at the Eastern Oregon Branch Experiment Station, Union, and were sired by four lines of breeding: Lionheart, David, Prince, and Union. The first three lines are from the Central Station, Corvallis, and the Union line is maintained at Union. The four lines have been closed to outside breeding since 1948. Sires used from these herds are performance-tested before being used.

It was found that the David bulls sired calves that were heavier off feed, had a higher rate of gain, and subsequently a heavier carcass. Lionheart-sired calves had the highest marbling score, carcass conformation score, and the most fat in the carcass. Prince calves were highest in USDA grade, and had the highest dressing percent. Union-sired calves were lowest in all traits, except for daily gain in the feed lot, where they were comparable to the Prince calves.

Year differences were not significant for dressing percent and marbling score, but were for the remainder of the dependent variables. Weights off feed, daily gains, and carcass weights were highest in 1960, followed by 1959

and 1958. USDA grade and carcass conformation were best in 1958, followed by 1960 and 1959. Carcasses had a higher percentage of fat in 1958, followed by 1959 and 1960.

Line x year interactions existed for weight off feed, carcass weight, USDA grade, dressing percent, and marbling.

The multiple regression model accounted for 57.52 percent of the variation in weight off feed, with weight on feed the only independent variable, other than lines and years, significantly affecting it. Thirty-four percent of the variation was accounted for in daily gain. Weight on feed had a significant effect on carcass weight. The model accounted for 96.93 percent of the variation in carcass weight. Thirty-three percent of the variation in USDA grade was accounted for by the model. Dressing percent was affected significantly by birth weight, carcass conformation, daily gain, and carcass weight; and the regression model accounted for 98.77 percent of the variation in dressing percent. Marbling score was not significantly affected by the variables in the model, and the analysis accounted for only 35.59 percent of the variation in the marbling score. Type and percent fat influenced carcass conformation scores to a significant extent, and 48.66 percent of the variation in the carcass score was found by the model. Seventy percent of the variation in percent fat was accounted for in the analysis.

Correlation coefficients were determined for all variables whether dependent or independent. Correlations involving type and condition score consistently showed negative relationships with performance characteristics. Because of calves being weaned on a constant date and put on and taken off feed on constant dates, negative correlations were found between some age and weight variables. Positive correlation coefficients between weaning age and weight on and off feed is explained on this basis. Positive correlations were found between suckling gains and subsequent weights. Correlations existing among the dependent variables were all positive. No association between marbling and percent fat was found in this study.

CONCLUSIONS

1. The differences found between lines of sires showed that the David line, although sometimes criticized for its conformation, sired calves that performed better than the other lines in the feed lot and subsequently yielded heavier carcasses. This kind of performance would be of more advantage to the commercial producer than excellent conformation, but it is not suggested that conformation be ignored when selecting animals to be used in the breeding herd. The Lionheart bulls, which sired calves that were nearly as high gainers as the Davids, had the best conformation scores, the most marbling, and the highest fat content in the carcass. Fat content was not excessive in any of the steers because of the age at which they were slaughtered (sixteen months). The calves sired by the Prince bull were lowest in rate of gain of any of the calves. Except for this trait, the Union bull used in the study did not sire good-performing calves, and their rate of gain was not comparable to those sired by the David or Lionheart bulls. The relationship of the Union bull with the cow herd may have worked to the disadvantage of the performance of the calves. The study shows the distinct genetic differences between the lines for the traits studied.

2. The environment influenced traits, as is noted by significant year effects. Interactions between lines and years indicated that genetically dissimilar animals responded differently to changing environment.

3. Correlations involving type or condition scores with performance traits showed that the scores were not indicative of good performance. They also showed the desirability of testing animals by performance rather than relying on subjective appraisals. None of the animals used in this study were excessively fat, as is shown by the lack of correlation between percent fat and marbling, and the low mean marbling score. Carcasses averaged between good and choice in USDA grade. The animals were young enough that they should have met with consumer preference as regards tenderness and fat content. A producer of comparable animals would also find that they were highly satisfactory from an economic standpoint.

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