ASPECTS OF RATE AND EFFICIENCY OF GAIN IN BEEF CATTLE AND HERITABILITY ESTIMATES

by

Huibert Doornenbal

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ABSTRACT

Nine purebred Hereford bulls which had been tested for rate and efficiency of gain at the University of British Columbia, were bred to 99 heifers, 11 heifers to each bull, obtained from commercial breeders.

Each of the offspring, a total of 84, was weaned at 400 pounds and then placed on an individual feeding test, using the same feeding schedule and the same concentrate ration as that used for the bulls.

At 800 pounds, the animals were slaughtered, rail graded and several carcass measurements were collected.

Daily rate of gain and feed efficiency were computed over three periods.

The following correlations were calculated: birth weight and daily gain during pre-weaning period; birth weight and daily gain during post-weaning period; daily gain during pre-weaning and post-weaning period; daily gain during post-weaning period and percentage lean in ribcut; daily gain during post-weaning period and carcass grade. The "r" value of each of the above calculations was found to be "low".

There was a very high correlation between rate and efficiency of gain for each of the three periods:

400 - 800 pounds, r = -0.98
400 - 600 pounds, r = -0.97
600 - 800 pounds, r = -0.98

A simple plan for home testing was outlined. This plan calls for selection on the basis of rate of gain during a test period of approximately 5 months. Animals enter the test period in groups with equal body weight and are full fed.

INTRODUCTION

In the past much emphasis has been placed on visual conformation in selection of breeding stock in beef cattle. In general, the only records available to beef cattle breeders have been showring winnings and subjective evaluations made by individual breeders. Ideals or standards of conformation were originally established because it was thought they were indicators of desirable production and carcass traits.

Previous studies have often shown little relationship between conformation and most economically important factors in beef cattle production. The need for more adequate measures of performance as aids to selection has led to the development of "Performance Testing." In order to be profitable, beef cattle must have the inherent ability to grow rapidly. Individual beef animals differ in their ability to grow and to convert, economically, feed into gains. Performance testing is a means of identifying individuals possessing superior productive qualities and it is also a way of evaluating sires for transmitting these qualities to their offspring. A great number of studies have shown that these variations are due, in part, to genetic influences, thus justifying selection for rate and economy of gain.

Purebred beef cattle breeders and commercial cattlemen have become increasingly interested in experiments dealing with these traits for economical production. Until recently, most research of this nature has been done outside of Canada. In 1952, with the support of the British Columbia Beef Cattle Growers' Association and the financial support of the Federal and Provincial Departments of Agriculture, the Department of Animal Husbandry of the University of British Columbia

initiated a Beef Bull Research Project in which twenty-three purebred bulls were tested for rate and efficiency of gain. Nine of these tested bulls were used in a progeny test carried out at the Dominion Range Experimental Farm at Kamloops.

The purpose of this study was to indicate:

1) The extent to which rate and economy of gain are heritable by way of a regression of offspring on sire.

2) To what extent rate and economy of gain are correlated.

3) How performance testing might be applied to the benefit of the beef cattle industry.

I. REVIEW OF LITERATURE

A. Heritability of rate of gain.

The concept of heritability concerns whether the differences observed between individuals arose because they started life with different genotypes or were exposed to different environmental influences. The expression of heritable characteristics can be changed by appropriate environment under which that genotype develops. Heritability, therefore, can be defined as the fraction of the observed variation due to genetic differences.

Estimates of heritability for rate of gain as reported in the literature are not consistent. The figures vary from about 10 to close to 100 percent. The Commonwealth Agricultural Bureaux, (1953-1954) in its Twenty-Fifth Annual Report, makes the statement (referring to rate of gain in beef cattle): "In a recent review of the interpretation of progeny tests, it was stated that 80-90% of the variation between progeny groups was non-genetic." Knapp and Nordskog (1946[a]), in a study made of the records of 177 steer calves from 23 sires, estimated the heritability of daily gain in the feed lot to be 99 percent. This figure was arrived at by the half-sib correlation method. Using the parent-offspring relation method, this estimate became 97 percent. Knapp and Clark (1950) revised their estimates to 65 percent and 77 percent respectively. A large number of investigators report heritability estimates for rate of gain which are between the two extremes mentioned above. Patterson, et al, (1949) reported on the rate of gain of animals tested for a period of 7 years. Six to 10 bull progeny per sire were tested, giving a total of 814 progeny. Using the half-sib correlation method, they concluded that heritability was extremely high for

this character, the actual numerical value being close to 100 percent. After collecting more data and improving the technique of analysis, Patterson, et al, (1954) revised this heritability figure to an average value of 53 percent.

Kohli, Cook and Dawson (1952), weaned 62 calves at 500 pounds and then fed individually, in a record of performance test, from 500 to 900 pounds live weight. Kohli, et al, found the heritability for average daily gain in the feed lot to be 63.6 percent. This coefficient agrees very closely with the revised figure of 65 percent obtained by Knapp and Clark (1950). Dawson, Yao and Cook, (1955), reporting on data from 58 Milking Shorthorn steers, representing the offspring of 9 bulls and 51 cows, estimated the heritability of average daily gain to be 18.8 percent.

Kincaid, et al, (1952) computed heritability of growth rate from gain data available for both sires and progeny. These varied from 0 to 42 percent and averaged 22 percent for 81 bulls fed individually and 12 percent for 55 heifers on pasture. Warwick, Cartwright and Hazen, (1954) report several heritability figures for gaining ability for groups of cattle with different genetic makeup.

In summary, these figures are as follows:

Group included	Number of Animals	Heritability Percent
All animals	863	38
Animals raised at BF	587	34
All Herefords	329	51
Herefords raised at BF	189	21
All Brahmans	124	46
Brahmans raised at BF	33	46
F_1 (Hereford x Brahman)	359	33

These values were computed from tests at four stations. The above values show considerable variability. Heritability applies

directly only to the group from which data are collected. In those combined studies, cattle went on test at different ages, weight and finish. Those factors, and differences in other environmental conditions, probably account for most of the variability in the results. These estimates were obtained by using the half-sib correlation method.

To overcome differences in number of animals, differences due to test year and breed, the data were analyzed on the basis of the gain ratio. The gain ratio was computed for each animal by dividing its total gain on test by the average total gain on test of animals of the same year, breed, sex and ration group and multiplying by 100.

Warwick, et al, (1954 and 1955) also report values using the second method of calculation, the regression of offspring-on-parent. According to Lush (1940) less bias is incorporated in estimates of heritability by use of this method. For this calculation, 68 parents with test records were paired with the average of their offspring (n = 147). The regression coefficient was 0.29 and heritability was estimated to be 57 percent. Five additional bulls had gain test records from another station but sired Bluebonnet tested calves. When this information was added (n = 291) the estimate changed slightly to 54 percent. Here again the gain ratio for each individual was computed before analysis. Shelby, Clark and Woodward (1955) calculated heritability of gain in the feed lot from data collected over a 10-year period (1942-1951) of Record of Performance testing at the U.S. Range Livestock Experiment Station at Miles City, Montana. Records of 635 steers from grade cows mated to 88 sires from 9 lines were available. This study uses the correlation between paternal half-sibs. Components of variance were estimated as outlined by Henderson (1953) in method 1. These investigators arrived

at a value of 60 percent. According to the authors, the major advantage of using paternal half-sib correlation to estimate heritability is that the resultant value contains only additive plus a small fraction of the epistatic portion of heredity variance. The accuracy of this method depends on the number of degrees of freedom available for estimating the differences between sires. It is limited by the fact that errors due to sampling or incorrect estimation of environmental influences are multiplied by 4.

Although there is much variability in the estimates of heritability of gain in the literature reviewed, the more reliable experimental results and the bulk of evidence suggest a substantial heritability figure, probably of the order of 65 percent.

B. Factors affecting rate and economy of gain.

Growth rate and economy of feed utilization are considered to be very complex and to involve innumerable genetic, physiological and environmental factors (Brody 1945).

a) Weight and age of dam:

Rollins and Guilbert (1954) reported on monthly weights of each of 159 purebred Hereford bull and heifer calves out of 57 cows. These investigators analyzed the relation between a calf's rate of growth from birth to 4 months and its 240-day weaning weight. They dealt with the question of culling cows, using the weight of the first calf at 3 months as a criterion. They found that the age of the dam had an effect on both periods, birth to 4 months and 4 months to weaning at 240 days. Dams in the range of 7 to 10 years produced calves that grew fastest to 4 months of age and were heaviest at weaning. However, from 4 to 8 months of age the calves from first calf heifers and, to a lesser extent from second calf cows, grew faster than those from the older age range. This is probably due to a greater persistency in lactation of young cows.

Knapp, et al, (1942[b]) found the optimum range for cow productivity to be 5 to 7 years. Koch and Clark (1955) indicate in their analysis of 4553 calves that maternal environment has considerable influence on birth weight, gain from birth to weaning and weaning score. For yearling gain and score, maternal environment appeared to be of little importance.

Dawson, et al, (1947) reported that birth weight of calves in the beef Shorthorn herd at Beltsville tended to increase at the rate of 0.2 pound per month of increase in the age of the dam until the dams were

6 years old, after which there was no affect of age of dam.

Weight of dam was found to be related to birthweight of calf to about the same extent as was age of the dam. They also found that the largest calves at birth and those with the highest prenatal growth rates tended to reach 500 pounds (weaning weight) and 900 pounds (slaughter weight) the soonest. Burris and Blunn (1952) found a definite relationship between age of dam and birth weight of calf. The maximum birth weight was not reached until the cows are 9 to 10 years old. Hitchcock, et al, (1955) reported a correlation of birthweight with age of dam of 0.45 for male calves and 0.36 for female calves. However, they stated that no evidence was found that age of the dam needs consideration when selection is based on yearling weights.

In summary, most studies report that weight and age of dam do have an influence on birth weight and growth-rate from birth to weaning. This, as will be pointed out later, is probably largely due to the milking ability of the dam. Most investigators indicate that there is little or no association between the environment of the dam and the growth rate and economy of gain during the period in the feed lot.

b) Gestation length:

Burris and Blunn (1952) indicate a high correlation between length of gestation and birth weight of calf. Differences in gestation length accounted for 7.9 percent of the variance in calf weights. Though a few sires seem to have considerable affect on gestation length, the analysis of the data showed that within breeds, sire affect alone was not significant. Sire as well as dam influence gestation length. Dawson et al (1947) found a significant but relatively low positive correlation between the length of gestation period and birth weight.

Unless birth weight has a significant influence on later growth, gestation length would not affect rate of gain.

c) Season of birth:

Koch and Clark (1955) indicate that the difference between the growth rates of the early and late calves is not as important as many people have thought. The regression figure arrived at was not sifnificantly different from zero. As the authors point out, the conflict between the facts of their findings and the impression that earlier calves appear to do better is no doubt due to the inability of a person to adjust mentally for differences in age when examining a group of calves of mixed ages.

d) Birth weight:

Dawson, Phillips and Black (1947) state that the correlation between birth weight or prenatal growth rate and economy of gain during the feeding period showed there was practically no association. There also was little relationship between birth weight and the length of the feeding period from weaning (500 pounds) to slaughter (900 pounds). Koch and Clark (1955) in evaluating the influence of maternal environment suggest in their comparisons that maternal environment from conception to birth and from birth to weaning had a large influence on birth weight, gain from birth to weaning and weaning weight, but a small influence on yearling gain. Dahmen and Bogart (1952), however, found that birthweight had a significant effect on economy of gain while on test. The calves that were largest at birth gained faster and were more efficient. They suggest that birth weight should be given consideration in selection in view of the fact that it had an influence on the time required for calves to attain a slaughter weight of 800 pounds.

They indicated that for every 1-pound increase in birth weight there is a corresponding 0.010 of a pound increase in gain per day during the test period and a 2-pound saving in total digestible nutrients for each 100-pound gain in live weight. They claim that 18 percent of the variance in economy of gain is accounted for by variations in birth weight. Pierce, et al, (1954) worked with stall-fed (individually) calves and lot-fed (10 calves in each lot) calves. They found that for the stall-fed calves, birth weight had a significant effect on gain on test and on gain from birth to the end of test. Calves 10 pounds heavier at birth gained 0.13 of a pound per day more on test, and 0.041 of a pound per day more from birth to the end of test. For lot-fed calves, an additional 10 pounds at birth resulted in 0.41 pound extra gain per day on test and 0.083 pound added gain per day from birth to the end of the test. In both cases in this study, calves heavier at birth gained faster on test and from birth to market.

Several estimates of heritability of birth weight have been reported in the literature. Knapp and Nordskog (1946[a]) estimated heritability of birth weight to be 42 and 34 percent; Dawson et al (1947) 29 percent; Knapp and Clark, (1950) 45 percent; Gregory et al, (1950) 45 percent and 100 percent; Burris and Blunn, (1952) 22 percent; Shelby, Clark and Woodward, (1955) 72 percent, and Koch and Clark (1955) 42 percent.

e) Suckling period:

Affects of suckling gain on performance later in the calf's life has been the object of considerable study. Gifford (1953) made an extensive study of the correlation between milk production of dams and growth of calves. One of the most striking observations made by Gifford

was the small amount of milk and butterfat produced by these cows. He was working with Herefords, Aberdeen-Angus and Shorthorns. The average production for all cows was 1,498 pounds of milk with an average butterfat test of 3.08 percent and 46.1 pounds of butterfat. The largest record made was 2,458 pounds of milk and 88.4 pounds of butterfat during a 244-day lactation, at an age of 12 years. The lowest producer was a 3-year old cow with a record of 312 pounds of milk and 14 pounds of butterfat in 236 days.

There was a considerable degree of correlation between the quantity of milk produced daily by the dams and the daily gain in weight in their calves during the first, second, third and fourth months. The gross correlations observed were 0.60, 0.71, 0.52 and 0.35, respectively. During the following 4 months the correlations were smaller in magnitude and not significant.

Cows producing less than 6.5 pounds of milk daily during maximum production failed to produce satisfactory calves. At weaning, 8 months, the average weight of this group was only 354 pounds. Cows that produced from 6.5 to 12.9 pounds daily during maximum production weaned calves with an average weight of 405 pounds, and cows that averaged more than 13 pounds daily during their highest producing periods weaned calves that averaged 475 pounds. The lowest producer with a maximum recorded production of only 2.3 pounds daily produced a stunted calf that weighed only 259 pounds at 8 months. The author pointed out that a minimum production of 6 to 8 pounds daily during the first 3 months was required to produce a 400-pound or larger calf at 8 months. The above study illustrates the great influence milk production of the dam has on the early growth of the calf, but it also indicates the

decreasing magnitude of this influence as the calf grows older, till this influence approaches zero at weaning time. Koch and Clark (1955) state that the maternal environment from birth to weaning appears negatively correlated, genetically, with weaning weight. Burris and Baugus (1955) found the same high correlation between milk production of the ewe and growth of their lambs. Early growth and milk production were highly correlated ($r = 0.83$). As the lambs grew older the correlation between growth and milk production in each 4-week period decreased rapidly. However, the total milk production and total growth of the lamb to 16 weeks were highly correlated ($r = 0.83$). Knapp et al (1941[b]) showed that 41 percent of the variation in rate of gain during the suckling period of beef calves was accounted for by differences in the amount of milk, hay and grain consumed and particularly in the amount of milk.

Dahmen and Bogart (1952) found that the variance in suckling daily gains had no significant affect on either rate or economy of gain in the feed lot. However, they suggest that suckling gains do have their importance in their value of measuring the milking ability of the dam; therefore, the use of gains during the suckling period in a selection index is worthwhile. Pierce, Avery, Burris and Bogart (1954) found no significant correlation between birth weight and suckling gain. Working with individually fed and lot-fed calves they stated that for individually-fed calves gain per day during the suckling period had no affect on gain on test or gain from birth to the end of the test. However, for lot-fed calves suckling gain had a significant positive affect on gain on test and on gain from birth to the end of the test. There was no explanation given why there was a difference in this respect

between individually fed and lot-fed calves. It could be that differences in weight and size at weaning (all calves were weaned between October 1st and 18th) accounted for differences in feed intake and, therefore, calves with a high daily growth rate during the suckling period were able to acquire more feed in lot-feeding, and hence correlation between suckling gain and gain at test would exist.

Knapp and co-workers (1941[b]) found no correlation between weaning weight, or suckling gain, and daily gain in the feed lot. They found high negative correlations of both weaning weight and suckling gain with efficiency in the feed lot, indicating the heavier the calf at weaning, the more feed is required for maintenance and efficiency decreases. This, of course, is only the case when calves are weaned at a constant age and not at a constant weight.

Koch and Clark (1955) found a negative genetic correlation between matornal environment and growth response.

Undoubtedly, maternal environment from conception to weaning accounts for a large proportion of variances between individual calves. However, if calves are put on test at a constant weight, which is as much a uniform physiological age as possibly can be achieved, much of the pre-test differences should not affect post-weaning gain, and the influence of suckling ability of the dam which accounts for most of the variation, (Gifford 1953) is greatly reduced.

f) Weaning weight:

Weaning gains and weaning weights are our best indicators of the milking ability of the dam. Koger and Knox (1951) found a small but significant negative correlation between weaning weight and long yearling gain. Knapp and Clark (1950) also showed low or non-significant

correlations with weaning weight and they indicate that this is to be expected, since weaning weight is largely a function of the dam's maternal ability. Koch and Clark (1955) found that maternal environment appeared to be of little importance for yearling gain and score or is even negatively related to the genes directly influencing these traits. These investigators indicate that the pre-weaning and post-weaning period are markedly different in the environments provided. In pre-weaning growth the calf is protected and nourished to a large extent by the cow, the gains of the calf and its final weaning weight being determined largely by available milk supply. In the post-weaning period rustling ability and the capacity to handle large quantities of roughage would be important factors in determining gains. Selection based on gains made up to weaning would be ineffectual in improving the genotypes for later gains. In a selection program for replacement cows, the weight of a calf at weaning would be a useful measure of its dam's productivity. Several investigators have reported the repeatability of weaning weight to be in the neighbourhood of 50 percent (Koger and Knox 1947; Koch, 1951; Gregory, 1950; Botkin and Whatley, 1953; Rollins et al, 1954; Koch and Clark, 1955 reported 34 percent). Heritability estimates for weaning weight reported in the literature are: Knapp et al (1946[a]) 12 percent and 30 percent; Knapp et al (1950), 28 percent; Koch and Clark (1955), 24 percent; Gregory et al (1950) working with 2 sources of data, reported 26 percent and 52 percent. A repeatability and heritability of this magnitude indicates that weaning weight of a cow's first calf could be used profitably as a criterion in such a program for replacement cows.

In summary, weaning weight, although important, is not indicative of a calf's genetic potentialities for growth. The calf's true inherited efficiency and ability to grow are displayed after weaning.

g) Sex:

The results of investigators in general agree that sex influences birthweight, weaning weight and rate and economy of gain.

The birth weight differences, because of sex, reported in the literature range from 4.2 to 5.8 with bull calves averaging about 4.7 pounds heavier than heifers (Burris and Blunn, 1952; Dawson et al, 1947; Gregory, Blunn and Baker, 1950; Knapp et al, 1942[b]; Koch and Clark, 1955). Koch and Schleicher (1955) report a difference of 6.7 pounds in favour of the bull calves at birth.

Significant differences in rate of gain prior to weaning have also been observed. Rollins and Guilbert (1954) estimated that bull calves on the average gained 0.13 pounds per day more than heifer calves from birth to 4 months of age. For a 240-day weaning weight bull calves were 68 pounds heavier than heifer calves. Koch and Clark (1955) found that the average difference between male and female calves at weaning was 26.2 pounds.

Koger and Knox (1945) indicated that steer calves outweighed heifer calves at weaning by 32 pounds. Bogart and Blackwell (1950) found that bulls gained faster and more efficiently than did heifers. Bulls gained on an average of 2.34 pounds per day while heifers gained 1.74 pounds. The heifers required 265 pounds more feed per 100 pounds gain than the bulls. Significant differences in rate of gain prior to weaning have also been observed, male calves gaining at a faster rate, by Black and Knapp (1936), Knapp and Black (1941[b]), Bloom (1953) and

and Koch (1951). Dahmen and Bogart (1952) found that beef animals possessing similar breeding and being exposed to the same environment show marked sex differences in growth rate and efficiency. In comparing bulls and heifers between 500 and 800-pounds, the average daily gain of bulls was 2.3 pounds as compared to 2.0 pounds for heifers. For every 100 pounds of gain the bulls required an average of 391 pounds of T.D.N., while the heifers required an average of 483 pounds of T.D.N.

When testing progeny and comparing sires, it appears to be necessary to apply correction factors for sex differences in the offspring.

h) Type:

The gaining and fattening ability of the "Regular" and "Comprest" types of Hereford steers has been a question in the minds of steer feeders for some time. Willey et al (1951) compared 7 regular and 7 comprest animals. These calves were self-fed for 112 days on a feed mixture calculated to promote normal growth. Following this, they received individually a feed mixture containing 59 percent concentrates for 173 days. In summary, the results of this 285-day feeding period were as follows:

	"Regular"	"Comprest"
Average initial weight	470	478
Average final weight	1,000 *	954
Gain per animal	530 *	476
Daily gain per animal	1.86 *	1.67
T.D.L. Lbs/100 lbs. of gain	645	674

* Difference significant at 0.05 level.

"Regular" type steers made higher gains on less feed than "Comprest" steers in this study. The difference in feeding efficiency was not

significant. The difference between expenses, as calculated in this test, and the carcass values resulted in an advantage of $8.42 per head in favour of the "Regular" steers. Cook et al (1951) in a study of live animal measurements reported that steers shorter in body and in height at withers and at the floor of the chest tended to grade slightly higher than more rangy steers. They studied data from steers killed at a constant weight. Woodward et al (1954) stated that the long-bodied steers in their experiment appeared to have carcasses as desirable as those of the short-bodied steers. They also remarked that the trend towards selection for short-coupled beef cattle could well be faulty considering the fact that most of the better cuts of beef are from the back.

Kohli et al (1951) found that steers which were shorter in height and length of body and smaller in circumference of foreflank were slightly superior in rate and economy of gain.

Stonaker et al (1952) found that compact type steer calves, when fed to a low choice slaughter grade, gained as efficiently per unit of feed eaten as did the conventional type calves. Koger and Knox (1952) conclude that selection for compactness in Hereford cattle was highly effective, indicating high heritability of body proportions.

i) Size and Age:

There is no doubt that size and age, because of their physiological effects upon production of body substance, influence rate and economy of gain. Brody (1945, p.49) states that the increase in size of a given animal associated with increasing age would be expected to increase the energy cost of its maintenance and reduce correspondingly the total efficiency of growth unless this increase in maintenance is

compensated by an increase in growth rate. In the case of different species, such as in cattle and chickens, there is such compensation and, therefore, nearly the same efficiency of growth, at equivalent physiologic ages. The increase in size associated with increasing age in the same animal, however, is not compensated for by an increase in growth rate, with the result that there is a decrease in efficiency of growth with increasing age or weight.

Hankins et al (1939) showed that efficiency of feed utilization was a straight-line function of live weight; efficiency decreases in direct proportion to increase in live weight. With increasing age, feed efficiency also decreased. Whiting (1955) reported that it costs 37 percent more to put 100 pounds of gain on from 800-900 pounds than from 400-500 pounds. The rate of gain increased as the body weight increased, but the cost of the gain went up more than directly proportional. Pierce et al (1954) found that age on test has a significant affect on gain on test.

Lambert (1936) states that the ability of an animal to convert feed into gain is dependent upon at least two factors, initial efficiency and rate of decline in efficiency. Efficiency, therefore, is a function of live weight. As an animal increases in age and size, there are corresponding changes in the physiological functions governing the utilization and deposition of nutrients.

j) Feed Utilization:

Baker, Colby and Lyman (1951) set up an experiment to find whether variation in digestion rates was in any way related to feed efficiency or rate of gain of the individual animals. Feed was analysed and fecal samples were collected by use of canvas bags. The data indicated

that digestion of crude fiber is possible one of the more important factors influencing feed efficiency. Animals that used the least feed per pound of gain seem to be superior in digesting crude fiber. These investigators suggest that the great differences that exist between animals in their ability to make gains lies in the utilization of their feed after it is absorbed rather than in differences between animals in ability to digest and absorb nutrients.

Brody (1945: 753) points out that "two animals may gain weight at different rates, yet gain energy at the same rate. This is because some types of weight gains involve greater energy storage per unit live weight than others. For instance, one gram of protein gain is necessarily associated with 3 grams of water gain, whereas one gram of fat gain is not so associated with water gain. The energy equivalent of one gram of fat is $2\frac{1}{4}$ times that of one gram of protein. Hence, one gram of fat gain is calorically equivalent to about 8 grams of protein gain (including associated water)." Therefore, inherent differences in animals that are exhibited in different rates of fat deposition in relation to weight gains, would have a pronounced affect on the amount of feed required per unit gain.

C. Correlation between rate and efficiency of gain.

A high correlation between rate and efficiency of gain seems to be a biological necessity. However, data from the literature indicate that the correlation is not always high. Guilbert and Gregory (1944) found that 2 groups of animals having the same efficiency of gain differed significantly in rate of gain and vice versa. Winters and McMahon (1933) report a correlation of 0.34 between rate and efficiency of gain. Knapp, et al., (1941) reported a correlation of 0.44. Woodward, et al., (1954) reported a correlation of 0.23 between rate and economy of gain. Higher correlations were reported by other investigators, Galgan, et al., (1955) 0.755; Pierce, et al., (1954) 0.82.

Knapp and Baker (1944) tested 66 steers sired by 9 bulls; 6 to 8 progeny from each bull made up each sire group.

These steers were individually fed for a 273-day period. The initial weight of the steers varied from 298 to 492 pounds and the final weights from 759 to 1134 pounds. The gain in the feed lot varied from 1.42 pounds to 2.48 pounds per day. The lot means of rate and efficiency showed a low relationship. The correlation between observed rate and gross efficiency of gain was 0.49. However, in this estimation of correlation between rate and economy of gain, animals were compared at different body weights. Kleiber (1936) stated that use of absolute rate of gain as an index of efficiency is applicable only to animals of the same size. At least 2 components, growth and maintenance, contribute to the utilization of feed by growing animals. The heavier the animal the higher the requirements for maintenance become.

Comparisons and selections on gross efficiency in time constant feeding periods are generally misleading and erroneous. Knapp and Baker

corrected this efficiency correlation figure of 0.49 by applying the law of diminishing returns, based on the curve of diminishing increment described by Spillman and Lang (1924). This curve expresses with a high degree of accuracy the relationship between live weight and feed consumption. This method of correction was applied to each of the 66 steers. The correlation between daily gain and this corrected efficiency of gain was found to be 0.83. The authors suggest that correcting to a weight constant basis or feeding on a weight constant basis tends to eliminate the errors introduced under time constant feeding. It is likely that those lower figures of correlations between rate and efficiency of gain mentioned earlier were not corrected for weight, but were based on a time constant feeding period and thus were misleading.

Guilbert and Gregory (1944) also pointed out that comparing beef animals fed on a time constant basis may introduce biased estimates of feed utilization where considerable variation in size and fatness exists. They proposed feeding cattle to a constant degree of fatness in testing for efficiency of feed utilization. Black and Knapp (1936) suggest that all steers be fed from 500 to 900 pounds in order to measure efficiency of feed utilization. Knapp and Baker (1944) conclude that comparisons of gross efficiency should be made only between animals of the same size.

Heritability figures for efficiency of gain reported in the literature are: Knapp and Nordskag (1946[a]) 75 percent (half-sib correlation) and 54 percent (regression of the average performance of the progeny on the performance of the sires and using the sire: offspring regression within groups of sires fed the same year (analysis of covariance) this estimate became 48 percent; Knapp and Clark (1950) 48 percent;

Dawson, et al., (1955) 3.2 percent; Shelby, Clark and Woodward (1955) 22 percent, and Kohli, et al., (1952) 25.6 percent. These estimates vary greatly, probably because of differences in breeds, populations, feeding and comparison at different body weights.

II. EXPERIMENTAL

A. Experimental Animals.

During the winter of 1952-1953, 23 bulls were tested for rate of gain and feed efficiency at the University of British Columbia.

These animals arrived at the University during the first half of November 1952 and were started on an individual feeding test on November 29th, 1952. This test ended after 147 days of feeding on April 25th, 1953. The animals were weighed weekly and an accurate record of the feed consumption was kept. At the end of the feeding period, 9 bulls were selected for performance testing of their progeny at the Range Experimental Farm at Kamloops. The bases of selection were: a) average daily gain, obtained by dividing total gain by the number of days on test; b) efficiency of gain, calculated from the total feed consumption divided by the total pounds of gain; c) weight for age basis (Doornenbal and Wood, 1952-1953, Table IX A).

Table 1.

Bull No.	Wt. at 180 days	Wt. at 270 days	Wt. at 360 days	Gain per Day:	Pound T.D.N. Per Lbs/Gain
200	520 (e)	710	955 (e)	2.37	4.01
199	478 (e)	705	908 (e)	2.34	3.96
207	490 (e)	680	895	2.16	4.53
205	-	663	838	2.00	5.07
203	-	553	732	2.13	4.61
202	431	605	815 (e)	2.04	4.21
204	387	535	725	1.92	4.40
206	-	468	670	2.14	4.34
201	397	540	725	1.90	4.66

e = estimated

Table 1 gives information relative to the bulls used in this test.

The heifers used in this performance test were supplied by 9 commercial cattlemen, each supplying 11 open heifers. These 99 heifers were divided into 9 groups of 11 animals as follows:

Each bull-group consisted of one heifer, taken at random, from each of the 9 breeders; the rest were at random divided over the 9 bulls to make up the total number of 11 heifers per bull-group.

During the summer of 1953, the heifers were kept on irrigated pasture and hand bred to the 9 bulls. A precise breeding date for each female was recorded.

Five heifers were lost during the pasture season from bloat. Two of the heifers were bred before arrival at the Station and calved in early winter; the rest of the heifers (92) calved during the spring and summer of 1954. Seven calves were still-born or died from various causes shortly after birth. Eighty-five calves were raised.

B. Feeding and management.

The feeding procedures used in the experiment were the same as those followed in the University of British Columbia bull test. The animals were fed twice daily to a feeding schedule shown in Table 2. Roughage was fed at 0.9 percent of the animal's weight and the concentrate allowance determined by adjusting the concentrate to a level equal to the difference between the total digestible nutrients of the standard and the digestible nutrients provided by the hay.

The concentrate ration used for the bull test at the University as well as for the test at Kamloops was University of British Columbia ration No. 50. The ingredients are listed in Table 3. After blending the constituents the ration was pelleted into one-half inch cylindrical pellets.

During the winter of 1953-1954, the bred heifers were fed 15 pounds of alfalfa hay and 3 pounds of whale solubles-barley-refuse screenings pellets per head per day. This ration was estimated to be sufficient for a gain of one-half pound per day.

During the summer of 1954, cows and calves were kept on irrigated pasture.

To eliminate as much as possible the differences in milking ability of the dams, the calves, while on pasture, were creepfed, using the same concentrate that was used during the dry-lot feeding period. Where there are differences in milking ability of the dam, creep-feeding favours genic value for growth response at the expense of the genic value for milking ability (Koch and Clark, 1955).

Cows and calves were weighed weekly. As soon as a calf reached

Table 2.

DAILY FEEDING SCHEDULE

Wt. of Animal	Roughage Intake - Pounds -		Concentrate Intake - Pounds -	
Pounds	Morning	Evening	Morning	Evening
300	1.3	1.4	3.1	3.2
325	1.4	1.5	3.3	3.3
350	1.6	1.7	3.4	3.5
375	1.7	1.7	3.6	3.6
400	1.8	1.8	3.7	3.7
425	1.9	1.9	3.8	3.8
450	2.0	2.0	3.9	3.9
475	2.1	2.2	3.9	4.0
500	2.2	2.3	4.0	4.1
525	2.3	2.4	4.1	4.1
550	2.5	2.5	4.2	4.2
575	2.6	2.6	4.2	4.3
600	2.7	2.7	4.3	4.4
625	2.8	2.8	4.4	4.4
650	2.9	2.9	4.4	4.5
675	3.0	3.1	4.5	4.5
700	3.1	3.2	4.6	4.6
725	3.2	3.3	4.6	4.7
750	3.4	3.4	4.7	4.7
775	3.5	3.5	4.7	4.8
800	3.6	3.6	4.8	4.8
825	3.7	3.7	4.8	4.9
850	3.8	3.9	4.9	4.9
875	3.9	4.0	4.9	5.0
900	4.1	4.1	5.0	5.0
925	4.1	4.2	5.0	5.1
950	4.3	4.3	5.1	5.1
975	4.4	4.4	5.1	5.2
1000	4.5	4.5	5.2	5.2

Table 3.

U.B.C. RATION NO. 50

Constituent	Pounds Per Ton
Ground oats	800
Ground barley	500
Molasses	100
Alfalfa Meal	100
Bone Meal	20
Oil Cake Meal	380
Bran	100
	2000

The proximate composition of the alfalfa hay and concentrate pellets is given in Table 4.

Table 4.

Constituent	Hay	Concentrate
Dry Matter	87.0%	89.2%
Protein (Nx6.25)	14.9	16.1
Ether extract	1.6	4.4
Crude fibre	30.4	9.7
Ash	7.5	5.1
Nitrogen Free Extract	32.6	53.9
Carotene (Micrograms/gm)	15	-

the weight of 400 pounds, it was weaned and put on dry-lot feeding. The weaned calves were housed 10 to a pen and had freedom of this pen except at feeding time when they were restrained with neck chains to permit accurate measurement of feed intake. They were fed twice daily according to the feeding schedule shown in Table 2.

When the calves reached 800 pounds, they were sent to market.

III. RESULTS

Table 1 in the appendix presents a summary of the recalculation of the performance test on the nine bulls used at the Experimental Farm at Kamloops. This recalculation (of Table 1 in the thesis) was necessary in order to compare rate and efficiency of gain of the bulls over an equal weight period.

Table 2, 3, and 4 in the appendix present a summary of the results of the performance test on 84 calves. One calf, no. 195, was sent to market before she reached the weight of 800 pounds and is not included in the analysis of the data. The three growth periods, 400 - 800 pounds, 400 - 600 pounds, and 600 - 800 pounds do not represent exactly a 400 or a 200 pound weight period. The calves were weighed weekly and the weights closest to 600 and 800 pounds were used as the start or end of an interval.

Table 5 in the appendix presents the data on all the carcasses. This table also presents some brief remarks, as reported by the graders, which in some cases give an indication why a certain grade has been designated.

IV. DISCUSSION

Originally, the nine bulls selected to be used at the Experimental Farm, Kamloops, were picked from a group of 19 on the presumed basis that three of them were high gaining bulls, three were medium and three were low gaining bulls, (Table 1).

The rating in this table is open to question. Bull no. 206 is in the low-gaining group but has a higher rate of gain than any in the medium group, and a higher efficiency than two in the medium-gaining group. Further, Bull no. 207 in the high group is somewhat less efficient than bull no. 202 in the medium group and than bull no. 206 in the low group. The differences in rate of gain are so slight (only 0.02 lbs. between no. 207 and no. 206) that the allocation appears unjustified by the data. An even more serious fault is that the method used in allocating the nine bulls to high, medium, and low gaining groups is unsound. Rate of gain in Table 1 was calculated by subtracting the initial weight from the final weight and dividing this by the number of days (147) on test. Efficiency of gain was calculated by dividing the total feed consumed during the test by the total gain. There was a considerable variation in initial and final weight of the animals. In calculating rate and efficiency, this was not taken into consideration.

The proper procedure is to make comparisons and ratings over an equal body-weight period. (Kleiber, 1936; Black and Knapp, 1936; Knapp and Baker, 1944; Brody, 1945; Wood, 1952-53, see page 18 and 19). Furthermore, this is the method required for the purpose of this study. It follows that a fundamental error in method was made in the original

rating and allocation of the nine bulls. This has required a re-calculation of rate and efficiency for the nine bulls using the correct basis of comparison.

In appendix Table 1, the author has recalculated the available information on the nine bulls, using the 600 - 800 pound period as a basis of comparison. This was the only weight period common to all nine bulls. The actual initial weight of bull no. 205 was 651 pounds so the 600 pound weight had to be estimated by extrapolation. Similarly, the actual final weights of bulls 202, 201, and 204 were 755 pounds, 764 pounds, and 738 pounds respectively so these were extrapolated to 800 pounds. These extrapolations were done by extending the growth curves as presented by Riley (1953).

Examination of appendix Table 1 reveals that the original allocation has, in some cases, changed drastically. All three high gaining bulls (Table 1) moved, two bulls to the medium and one to the low gaining group (appendix Table 1). Two of the low gaining and one of the medium group (Table 1) comprise the high gaining group in appendix Table 1.

Another observation is that in appendix Table 1 the bulls, with one minor exception, rank in the same order on efficiency as they do on rate of gain. This result is expected because of the very high correlation (see page 36) between rate and efficiency. In Table 1, however, the bulls rank in markedly different order on efficiency to what they do on rate of gain. This is a further indication that the method used in rating and ranking the bulls (Table 1) was seriously at fault.

Further examination of appendix Table 1 shows that there is actually very little difference between the nine bulls in rate and

efficiency of gain. Six of the nine bulls are very similar for these traits and only two bulls, 202 and 204, show a slightly higher merit and only one bull, 205, shows a slightly lower merit.

With such a great similarity among the sires, one would not expect much difference in rate and efficiency of gain between progeny groups, providing these traits are highly heritable. This expected similarity in offspring actually occurred as shown by the progeny group comparisons (Table 5, 6, and 7).

Table 7 presents a summary of the analysis of variance components by weighted squares of means according to the method outlined by Goulden (1952). This method takes into account sex differences in rate of gain.

Over the 400 - 600 pound and the 600 - 800 pound periods, there is no statistically significant difference for average rate of gain between the groups. Only over the 400 - 800 pound period can statistical significance be demonstrated for average daily rate of gain between the groups.

The fact that statistical significance can be demonstrated for the 400 - 800 lb. period and not for the 400 - 600 or 600 - 800 period is, probably, a reflection of the fact that the averages are based on more weighings in the former case; in other words the samples are larger.

The group with the high average daily rate of gain, one can state with some confidence, gains more rapidly than the groups characterized by low averages daily rates of gain.

For each of the three periods there is a highly significant difference in average rate of gain between males and females. This is

Table 5

Mean Daily Gain of all Animals in each Bull-Group

Bull No.	400-800 lbs. Ave. daily gain	Rank	400-600 lbs. Ave. daily gain	Rank	600-800 lbs. Ave. daily gain	Rank
199	1.65	5	1.65	4	1.68	5.5
200	1.76	1	1.72	2	1.82	1
207	1.70	2	1.75	1	1.68	5.5
205	1.66	6	1.60	6	1.72	2.5
203	1.67	3.5	1.62	5	1.72	2.5
202	1.67	3.5	1.70	3	1.66	7
204	1.55	9	1.48	9	1.64	8.5
206	1.58	8	1.54	7	1.64	8.5
201	1.59	7	1.50	8	1.69	4

in agreement with all other investigators who found that males grow at a faster rate than females. (Koch and Clark, 1955; Burris et al, 1952; Dawson et al, 1947; Gregory et al, 1950; Knapp et al, 1942[b]).

There appears to be no significant difference in rate of gain within sex and within group.

Table 6

Mean Daily Gain of Animals in each Bull-Group by Sex

Bull No.	400-800 lbs. Ave. daily gain		400-600 lbs. Ave. daily gain		600-800 lbs. Ave. daily gain	
	M.	F.	M.	F.	M.	F.
199	1.73	1.58	1.63	1.66	1.86	1.50
200	1.87	1.65	1.78	1.65	1.98	1.66
207	1.81	1.59	1.85	1.65	1.81	1.55
205	1.75	1.57	1.67	1.54	1.85	1.60
203	1.73	1.60	1.66	1.59	1.82	1.63
202	1.79	1.55	1.81	1.60	1.80	1.51
204	1.63	1.48	1.54	1.41	1.72	1.55
206	1.73	1.43	1.63	1.46	1.84	1.45
201	1.69	1.48	1.57	1.43	1.82	1.56

Table 7

Summary of Analysis of Variance Components by Weighted Squares of Means

a. 600 - 800 pound period

Interaction:	S.S.	D.F.	M.S.	Calculated F	Tabled F @ p= 0.05	Tabled F @ p= 0.01
Between groups	0.2024	8	0.02530	0.6587	2.08	2.79
Between sex	1.4203	1	1.42030	36.9773	3.99	7.04
Sex x group	0.0775	8	0.00969	0.25228	2.08	2.79
Error	2.5348	66	0.03841	--	--	--

b. 400 - 600 pound period

Interaction:	S.S.	D.F.	M.S.	Calculated F	Tabled F @ p= 0.05	Tabled F @ p= 0.01
Between groups	0.158374	8	0.019797	0.698652	2.08	2.79
Between sex	0.308124	1	0.308124	10.873941	3.99	7.04
Sex x group	0.091649	8	0.011456	0.404291	2.08	2.79
Error	1.870200	66	0.028336	--	--	--

c. 400 - 800 pound period

Interaction:	S.S.	D.F.	M.S.	Calculated F	Tabled F @ p= 0.05	Tabled F @ p= 0.01
Between groups	0.2748	8	0.03435	2.1309 *	2.08	2.79
Between sex	0.7452	1	0.74520	46.2159	3.99	7.04
Sex x group	0.0439	8	0.005488	0.34045	2.08	2.79
Error	1.0642	66	0.01612	--	--	--

* There appears to be a slight difference between groups over the 400 - 800 pound period.

Correlations:

Most workers have found that growth during the pre-weaning period is largely independent of birth weight. They indicate that maternal environment from conception to birth largely influences birth weight. Rate of gain during the pre-weaning period, according to these workers, is largely dependent on the milk production of the dam.

In calculating the correlation between birth weight and daily gain during the pre-weaning period for the 84 offspring in this project, it was found that there was a very "low" correlation, $r = 0.27$ which might imply that maternal environment, such as suckling ability of the dam, largely influences daily gain from birth to weaning, as has been indicated by other investigators.

The correlation between birth weight and post-weaning growth, also was "low" ($r = 0.36$). The correlation between daily gain during the pre-weaning and post-weaning periods, was "low" ($r = 0.41$). This is in agreement with other workers: (Koger and Knox, 1951; Knapp and Clark, 1950; Koch and Clark, 1950).

It would appear that birth weight, weaning gains and weaning weights are mainly indicators of maternal environment and milking ability of the dam. During the pre-weaning period the true inherited ability to grow is largely masked by maternal environment, but is displayed during the post-weaning period.

These views are supported by other workers e.g. Gifford (1953) who found a high correlation between rate of gain during the suckling period and milk production of the dam, $r = 0.60$ for the first month and $r = 0.71$ for the second month. Burris and Baugus (1955), working with sheep, found a high correlation ($r = 0.90$)

between growth of lambs and milk production of the ewes.

To determine whether a relationship exists between rate and efficiency of gain and the amount of lean and fat in the carcass, a tracing of the rib section between the 11th and 12th rib was taken on all the carcasses by the Livestock Marketing Service personnel in Vancouver. From these tracings, with the use of a planimeter, the percentage lean and fat (exclusive of bone) in the rib sections was determined. This information has been recorded in appendix Table 5.

The correlation between daily gain during the post-weaning period and the percentage lean in the ribcut was ($r = 0.35$). Carcass evaluation is an important part of performance testing. Of the 84 carcasses, exactly half graded A. To establish if there was any relationship between a rate of gain and grading, a "chi - square" test was applied.

X^2 test for rate of gain and carcass grade
(2 x 3 contingency table)

	A	B	C*	
High rate of gain: ≥ 1.65	22 (23)	20 (18.6)	4 (4.4)	46
Low rate of gain: < 1.65	20 (19)	14 (15.4)	4 (3.6)	38
	42	34	8	84

* Note: There was one grade D_1; this grade has been included in the C grades.

$X^2 = 0.409$ D.F. $= (3-1)(2-1) = 2$

X^2 for 2 d.f. @ $p = 0.05$ $= 5.99$

The result indicates that the null hypothesis is true, or in other words, the distribution of carcass grades is independent of the daily rate of gain.

Correlation between rate and efficiency of gain.

Undoubtedly the most important correlation in this project is that between rate and efficiency of gain. The importance of selection for efficiency has been stressed by many investigators.

In each of the three periods the correlation between rate and feed consumption per unit of gain was found to be very high:

400 - 800 pound period: $r = -0.98$

400 - 600 pound period: $r = -0.97$

600 - 800 pound period: $r = -0.98$

This means that animals with a high rate of gain used less feed per pound gained than did animals which had a low rate of gain.

Although these figures are slightly higher than those reported by some investigators: (Roubicek, 1951, $r = 0.87$; Galgan 1955, $r = -0.75$; Pierce 1954, $r = 0.82$; Knapp 1944, corrected, $r = 0.83$) they are of the same order of magnitude and highly significant. Some other workers have found much lower values, but as has been stated in the literature review, some of these figures have been obtained by comparing animals on the unsound unequal-body-weight basis.

Heritability estimates were intended to comprise an important part of this thesis. As has already been pointed out the actual differences between the nine sires used were extremely small and as expected the differences between their progeny groups were also extremely small. Consequently, this experimental material is unsatisfactory for the calculation of heritability estimates for rate and efficiency of gain.

Although none have been calculated for this project many workers have recorded heritability estimates as outlined in the literature review. These investigators indicate that a considerable

portion of variations in rate and efficiency of gain is under genetic influence. Because of this inheritance, selection for these traits is of major importance.

If the present beef cattle population is to be improved by breeding in order to increase the proportion of animals that make rapid and efficient gains, it is essential that a policy be developed for performance testing of beef cattle that will be adaptable to practical procedures in livestock breeding.

Differences among animals in the ability to use feed efficiently are difficult to measure accurately under practical farming conditions. Because of the very high correlation that exists between rate of gain and efficiency of gain, a simple production test where rate of gain only is measured (without recording feed consumption of animals on test) is justified.

Such a program could be briefly outlined as follows:

a) All cattle have to be permanently marked for identification. Ear-tags or neck chains with numbers can be used but it is advisable to use an ear tattoo as well, as tags often get lost.

b) Record the birth date of all calves.

c) Weigh all calves at weaning time.

d) If there is a period for adjustment after weaning, weigh all calves at date of entry on feeding test.

e) Select cattle for a uniform weight when entering the feeding test.

f) Weigh cattle at the conclusion of the test, which lasts for approximately 5 months.

g) During the test, animals are full fed.

Weaning weights are indicative of the lactating ability of the dam, a factor important in beef production and beef cattle selection. When animals of the same age are compared at weaning time, a breeder can use this information in culling and replacing his cow herd.

The gains made during the feeding period are largely indicative of the inherited ability to grow. The daily gain during this period is calculated by dividing total gain during the test by the number of days on test.

Providing the animals started the test at equal body weight, are full fed and kept under the same environment, differences in daily rate of gain during this period are largely due to inherited differences in gaining ability.

This performance testing is quite simple and could be put into practice by any breeder.

The purebred breeder can use it in a selection program on his bulls. It provides him with records that are useful for possible progeny testing of his sires and it provides valuable information for his customers, the commerical cattle breeders. In purebred herds where these production records have been kept, the commercial beef producer is able to buy bulls on the basis of these records as well as on type and conformation.

The commercial breeder can use performance testing as a tool to evaluate his sires as a group and his cow herd and also in a replacement program where he can test his young female stock for subsequent replacement of his cows as required.

This type of performance testing not only puts emphasis on high rate of gain (and efficiency) but it also facilitates elimination

of poor milk producers, shy breeders, and other kinds of inferior offspring from a herd.

This kind of performance testing has been started in the United States and even after a few years, the results are showing very markedly and many commercial breeders who buy bulls from purebred breeders, pay a considerable premium for bulls on which information on rate of gain is available.

Undoubtedly, in the near future, pedigree, type and conformation alone will not be sufficient as bases of evaluating beef cattle. Information on production will be added.

In the future it would be possible to establish the same principle of comparison in evaluating production in beef cattle, as has been established in the Holstein and Ayrshire breeds, where the production of the individual is compared with the National Breed Class Average. Such a program would be of great value in producing more rapidly gaining and more efficient animals in our beef breeds.

Recommendations to breeders:

1) To the breeder, purebred or commercial, it is recommended that he give rate of gain first consideration, being careful in obtaining and evaluating records.

2) A simple home test is all that is necessary to obtain valuable information on rate of gain.

Equipment required

a) record book

b) scales

c) device to mark cattle for identification (ear tattoo and/or tags)

Records to be kept

a) date of birth

b) weaning weight

c) initial weight on test

d) final weight on test and average daily gain during test.

3) Animals enter test at an equal body weight in order to be able to compare rate of gain during the test period on a sound basis.

4) While on test, all animals are full fed.

5) Male as well as female offspring should be tested for approximately 5 months.

6) Weaning weight, keeping age in mind, is valuable indicator of the milking ability of the dam and therefore, should be used as part of the basis for culling cows.

SUMMARY

During the winter of 1952-53, 19 Hereford bulls were tested for rate and efficiency of gain at the University of B.C. Out of this group, 9 bulls were rated and selected to be used for a progeny test at Kamloops. The 9 sires were bred to 99 heifers and their offspring were tested for rate and efficiency of gain.

The 84 offspring were weaned at 400 pounds and then put on dry lot feeding and individually fed until weight of 800 pounds was reached at which time they were sent to market.

Rate and efficiency of gain were calculated for each animal over three periods: 400-800 pounds, 400-600 pounds, and 600-800 pounds (Tables 2,3, and 4 in the appendix). In Table 5, appendix, information on the carcasses has been recorded.

Because of rating and dividing of the bulls in a high, medium and low gaining group on an unsound basis, this information in Table 1 was recalculated and recorded in appendix Table 1. There appeared to be a great similarity among the bulls for rate and efficiency of gain and this was reflected in their progeny. Analysis of variance revealed no significant difference between progeny groups for these traits. There was a highly significant difference for rate of gain between sexes, but no significant difference for rate of gain within sex and within group.

The following correlations were calculated:

a) Birth weight and daily gain during pre-weaning period ($r = 0.27$).

b) Birth weight and daily gain during post-weaning period ($r = 0.36$).

c) Daily gain during pre-weaning and post-weaning periods ($r = 0.41$).

d) Daily gain during post-weaning period and percentage lean in ribcut ($r = 0.35$).

e) A "chi-square" calculation for rate of gain and carcass grade indicated that the distribution of grades was independent of daily rate of gain during the post-weaning period.

The "r" value of each of the above calculations was found to be "low".

There was a very high correlation between rate and efficiency of gain for each of the three periods:

400 - 800 pounds, $r = -0.98$
400 - 600 pounds, $r = -0.97$
600 - 800 pounds, $r = -0.98$

A simple test, to be used by the individual farmer, is outlined, in which animals are tested for rate of gain only, so that no individual feed consumption records are required to be kept.

The animals enter the test at equal body weight and are evaluated on individual daily rate of gain during an approximate test period of 5 months.

Appendix Table 1

PROGENY TEST BULLS

Bull No.	Age at 600 lbs.	Weight	Age at 800 lbs.	Weight	Days 600-800 lbs.	Total Gain	Gain Per Day	Feed/lb.of Gain		Lbs.T.D.N. Per 100 Lbs.Gain
								Hay:	Conc:	
200	220	597	304	794	84	197	2.35	2.60	3.86	400.00
199	227	601	318	800	91	199	2.19	2.84	4.17	433.61
207	232	596	323	806	91	210	2.31	2.61	3.92	404.46
202	268	600	347	800	79	200	2.53	2.40	3.57	370.23
203	291	595	389	808	98	213	2.17	2.78	4.15	429.56
205	232	600	340	791	108	191	1.77	3.43	5.12	529.81
201	300	595	386	800	86	205	2.38	2.51	3.77	389.24
204	302	597	384	800	82	203	2.48	2.46	3.65	378.76
206	330	600	414	796	84	196	2.33	2.64	3.89	404.29

Appendix Table 2

B U L L N o . 2 0 0

Calf No.	Sex	Wt. at B.*	Wt. at W.*	Age at W.	Avg. Daily Gain B-W	Wt. at S.*	Age at S.	Days from 400-800 lbs.	Avg. Daily Gain 400-800	Carc. Grade	Feed/lb.Gain Hay:	Feed/lb.Gain Conc:	Lbs. T.D.N. Per 100 lb.Gain
108	-	--	---	---	---	---	---	---	---	-	---	---	---
114	M	73	400	166	1.97	808	376	210	1.94	B	2.66	4.33	436.1
128	-	--	---	---	---	---	---	---	---	-	---	---	---
135	M	74	400	146	2.23	802	342	196	2.05	C	2.50	4.09	411.3
150	M	79	400	165	1.95	814	382	217	1.91	B	2.77	4.48	452.1
163	F	66	402	160	2.10	816	398	238	1.74	A	3.03	4.90	494.8
169	M	80	404	152	2.13	806	376	224	1.80	A	2.97	4.76	481.3
186	M	67	406	186	1.82	808	445	259	1.55	C	3.43	5.26	539.9
192	F	75	414	167	2.03	800	405	238	1.62	A	3.30	5.31	536.7
138	M	73	408	173	1.94	824	383	210	1.98	B	2.71	4.34	439.3
168	F	76	400	225	1.44	802	477	252	1.60	A	3.20	5.10	516.9
Average:		73.7		171.1	1.96		398.2	227.1	1.80		2.95	4.73	478.7

* = B - Birth
W - Weaning
S - Slaughter

Appendix Table 2 (Cont.)

BULL No. 199

Calf No.	Sex	Wt. at B.✱	Wt. at W.✱	Age at W.	Avg. Daily Gain B-W	Wt. at S.✱	Age at S.	Days from 400-800 lbs.	Avg. Daily Gain 400-800	Carc. Grade	Feed/lb.Gain Hay:	Feed/lb.Gain Conc:	Lbs. T.D.N. Per 100 Lb.Gain
102	M	77	400	165	1.96	800	389	224	1.79	A	2.89	4.73	476.1
119	M	76	402	195	1.67	802	440	245	1.63	C	3.13	5.02	507.6
126	F	72	404	188	1.77	812	433	245	1.67	A	3.21	5.14	520.2
134	F	75	400	174	1.87	802	405	231	1.74	A	3.04	4.87	492.9
146	M	84	400	176	1.80	800	393	217	1.84	B	2.75	4.53	454.9
164	M	55	412	184	1.94	800	429	245	1.58	A	3.32	5.35	540.5
175	F	76	412	191	1.76	800	485	294	1.32	A	3.96	6.33	641.2
187	-	--	---	---	---	---	---	---	---	---	---	---	---
188	-	--	---	---	---	---	---	---	---	---	---	---	---
172	M	68	400	181	1.83	812	419	238	1.73	B	3.09	4.94	499.9
112	M	70	410	183	1.86	800	400	217	1.81	A	2.84	4.61	464.4
Average:		72.6		181.9	1.83		421.4	239.6	1.68		3.14	5.06	510.9

✱ = B - Birth
W - Weaning
S - Slaughter

Appendix Table 2 (Cont.)

BULL No. 207

Calf No.	Sex	Wt. at B.ǂ	Wt. at W.ǂ	Age at W	Avg. Daily Gain B-W	Wt. at S.ǂ	Age at S.	Days from 400-800 lbs.	Avg. Daily Gain 400-800	Carc. Grade	Feed/lb.Gain Hay:	Feed/lb.Gain Conc:	Lbs. T.D.N. Per 100 Lb.Gain
106	M	78	406	154	2.13	800	357	203	1.94	A	2.76	4.41	447.0
121	M	68	400	175	1.90	802	399	224	1.79	A	2.78	4.64	463.9
131	-	--	---	---	---	---	---	---	---	-	---	---	---
137	F	72	400	221	1.48	802	494	273	1.47	C	3.56	5.78	582.9
153	F	70	424	184	1.92	800	429	245	1.53	B	3.39	5.53	556.9
156	M	72	416	170	2.02	800	394	224	1.71	A	3.06	4.93	498.5
166	M	76	400	200	1.62	814	431	231	1.79	B	2.97	4.75	480.6
183	M	68	414	210	1.65	810	427	217	1.82	A	2.93	4.68	473.7
196	F	81	400	183	1.74	806	414	231	1.76	B	3.03	4.85	490.9
155	M	68	402	173	1.93	810	390	217	1.88	A	2.78	4.52	455.4
129	M	71	402	193	1.72	806	424	231	1.75	B	2.95	4.90	490.1
Average:		72.4		186.3	1.81		415.9	229.6	1.74		3.02	4.90	494.0

ǂ = B - Birth
W - Weaning
S - Slaughter

Appendix Table 2 (Cont.)

B U L L N o . 2 0 5

Calf No.	Sex	Wt. at B.✱	Wt. at W.✱	Age at W.	Avg. Daily Gain B-W	Wt. at S.✱	Age at S.	Days from 400-800 lbs.	Avg. Daily Gain 400-800	Carc. Grade	Feed/lb.Gain Hay:	Feed/lb.Gain Conc:	Lbs. T.D.N. Per 100 lb.Gain
101	M	88	402	205	1.53	822	457	252	1.67	B	3.17	5.05	512.3
115	M	82	414	183	1.81	800	400	217	1.78	C	2.97	4.80	484.7
127	-	--	---	---	---	---	---	---	---	-	---	---	---
139	M	64	406	212	1.61	804	443	231	1.72	B	3.09	4.98	502.9
149	M	67	400	198	1.68	818	443	245	1.71	B	3.01	4.96	497.94
159	M	63	414	177	1.98	802	394	217	1.79	B	2.96	4.77	482.5
170	F	65	406	187	1.82	806	418	231	1.73	B	3.00	4.83	488.3
179	M	78	402	170	1.91	824	401	231	1.83	B	2.87	4.66	469.7
191	F	58	400	208	1.64	800	460	252	1.59	A	3.29	5.37	540.5
182	F	62	402	217	1.57	816	490	273	1.52	B	3.49	5.61	567.3
190	F	65	410	181	1.91	804	454	273	1.44	B	3.60	5.89	592.7
Average:		69.2		193.8	1.75		436	242.2	1.68		3.15	5.09	513.9

✱ = B - Birth
W - Weaning
S - Slaughter

Appendix Table 2 (Cont.)

B U L L N o . 2 0 3

Calf No.	Sex	Wt. at B.ǂ	Wt. at W.ǂ	Age at W.	Avg. Daily Gain B-W	Wt. at S.ǂ	Age at S.	Days from 400-800 lbs.	Avg. Daily Gain 400-800	Carc. Grade	Feed/lb.Gain Hay:	Feed/lb.Gain Conc:	Lbs. T.D.N. Per 100 lb.Gain
107	F	66	404	203	1.67	810	455	252	1.61	B	3.29	5.28	534.3
111	M	61	400	155	2.19	800	393	238	1.68	B	3.05	5.03	504.4
124	-	--	---	---	---	---	---	---	---	-	---	---	---
142	M	74	412	172	1.97	800	375	203	1.91	C	2.70	4.41	444.1
151	F	63	400	184	1.83	806	450	266	1.53	A	3.40	5.51	555.9
160	M	75	400	142	2.29	814	394	252	1.64	C	3.14	5.14	516.6
173	M	74	406	238	1.39	800	462	224	1.76	D_1	2.95	4.74	479.2
181	M	70	410	189	1.80	810	427	238	1.68	B	3.14	5.06	511.4
193	F	63	410	194	1.79	820	439	245	1.67	A	3.15	5.10	514.1
145	-	--	---	---	---	---	---	---	---	-	---	---	---
105	F	71	410	181	1.87	804	426	245	1.61	A	3.24	5.25	529.4
Average:		68.6		184.2	1.87		424.5	240.3	1.68		3.12	5.06	509.9

ǂ = B - Birth
W - Weaning
S - Slaughter

Appendix Table 2 (Cont.)

BULL No. 202

Calf No.	Sex	Wt. at B.*	Wt. at W.*	Age at W.	Avg. Daily Gain B-W	Wt. at S.*	Age at S.	Days from 400-800 lbs.	Avg. Daily Gain 400-800	Carc. Grade	Feed/lb.Gain Hay:	Feed/lb.Gain Conc:	Lbs. T.D.N. Per 100 lb.Gain
100	M	80	402	171	1.88	802	416	245	1.63	B	3.16	5.09	514.3
113	F	71	400	193	1.70	800	424	231	1.73	A	2.99	4.88	491.1
122	F	70	400	240	1.38	804	499	259	1.56	A	3.36	5.43	548.3
136	M	82	404	187	1.72	800	404	217	1.82	B	2.87	4.46	455.4
147	F	76	400	190	1.71	800	449	259	1.54	B	3.40	5.44	550.7
158	F	69	404	179	1.87	802	431	252	1.58	B	3.30	5.28	534.6
174	F	64	410	242	1.43	800	522	280	1.39	B	3.78	6.09	615.2
184	M	82	402	158	2.03	808	368	210	1.93	A	2.68	4.38	440.8
161	-	--	---	---	---	---	---	---	---	---	---	---	---
180	F	63	402	258	1.31	806	531	273	1.48	B	3.43	5.58	562.4
Average:		73.0		202	1.67		449.3	247.3	1.63		3.22	5.18	523.6

* = B - Birth
W - Weaning
S - Slaughter

Appendix Table 2 (Cont.)

B U L L N o . 2 0 4

Calf No.	Sex	Wt. at B.*	Wt. at W.*	Age at W.	Avg. Daily Gain B-W	Wt. at S.*	Age at S.	Days from 400-800 lbs.	Avg. Daily Gain 400-800	Carc. Grade	Feed/lb.Gain Hay:	Conc:	Lbs. T.D.N. Per 100 Lb.Gain
110	F	69	402	197	1.69-	804	463	266	1.51	A	3.41	5.54	558.6
118	F	60	412	218	1.61	816	498	280	1.44	A	3.56	5.70	577.0
130	M	65	406	251	1.36	806	503	252	1.59	A	3.27	5.30	534.4
143	M	73	406	154	2.16	800	371	217	1.82	A	2.85	4.67	469.1
148	M	74	400	175	1.86	814	448	273	1.52	A	3.43	5.50	556.1
165	-	--	---	---	---	---	---	---	---	-	---	---	---
176	-	--	---	---	---	---	---	---	---	-	---	---	---
178	M	71	402	195	1.70	802	426	231	1.73	B	3.02	4.90	494.3
189	M	73	408	229	1.46	812	481	252	1.60	B	3.28	5.11	521.3
197	M	79	400	174	1.84	804	440	266	1.52	A	3.33	5.30	537.6
140	-	--	---	---	---	---	---	---	---	---	---	---	---
Average:		70.5		199.1	1.71		453.8	254.6	1.59		3.27	5.25	531.1

* = B - Birth
W - Weaning
S - Slaughter

Appendix Table 2 (Cont.)

B U L L N o . 2 0 6

Calf No.	Sex	Wt. at B.*	Wt. at W.*	Age at W.	Avg. Daily Gain B-W	Wt. at S.*	Age at S.	Days from 400-800 lbs.	Avg. Daily Gain 400-800	Carc. Grade	Feed/lb.Gain Hay:	Conc:	Lbs. T.D.N. Per 100 lb.Gain
104	F	65	404	189	1.79	812	497	308	1.32	A	4.03	6.40	649.7
120	M	65	404	174	1.96	800	405	231	1.71	A	3.08	4.96	500.8
132	-	--	---	---	---	---	---	---	---	-	---	---	---
141	M	76	400	187	1.73	810	446	259	1.58	B	3.29	5.34	538.2
154	M	80	404	160	2.03	810	426	266	1.53	B	3.51	5.63	569.6
157	M	76	400	171	1.89	800	395	224	1.79	A	2.92	4.74	478.1
171	M	70	418	181	1.92	802	405	224	1.71	A	3.07	4.98	502.2
177	M	73	410	170	1.98	822	373	203	2.03	A	2.60	4.21	425.2
194	F	75	400	167	1.95	808	440	273	1.49	A	3.49	5.63	569.0
125	-	--	---	---	---	---	---	---	---	-	---	---	---
152	F	57	408	215	1.63	802	481	266	1.48	B	3.52	5.75	578.4
Average:		70.8		179.3	1.87		429.8	250.4	1.63		3.28	5.29	534.6

* = B - Birth
W - Weaning
S - Slaughter

Appendix Table 2 (Cont.)

B U L L N o . 2 0 1

Calf No.	Sex	Wt. at B.*	Wt. at W.*	Age at W.	Avg. Daily Gain B-W	Wt. at S.*	Age at S.	Days from 400-800 lbs.	Avg. Daily Gain 400-800	Carc. Grade	Feed/lb.Gain Hay:	Feed/lb.Gain Conc:	Lbs. T.D.N. Per 100 lb.Gain
103	M	76	408	158	2.10	814	389	231	1.76	A	2.92	4.77	480.0
117	F	71	408	168	2.01	800	420-	252	1.56	A	3.31	5.37	541.4
123	F	63	410	251	1.38	810	510	259	1.54	B	3.47	5.54	561.3
133	M	67	404	173	1.95	806	404	231	1.74	A	2.95	4.73	478.8
144	F	68	406	196	1.72	802	504	308	1.29	A	4.09	6.30	645.6
162	F	56	402	207	1.67	804	487	280	1.44	A	3.61	5.82	588.0
167	M	71	402	178	1.86	820	458	280	1.49	A	3.54	5.62	570.1
185	F	66	400	203	1.65	806	441	238	1.71	B	3.05	4.97	500.4
198	M	77	410	152	2.19	804	390	238	1.66	A	3.11	5.13	514.4
116	M	70	404	176	1.90	804	400	224	1.79	B	2.92	4.72	476.6
109	F	64	404	213	1.60	802	507	294	1.35	A	3.82	6.05	614.1
Average:		68.1		188.6	1.82		446.4	257.7	1.58		3.34	5.37	542.8

* = B - Birth
W - Weaning
S - Slaughter

Appendix Table 3

B U L L N o . 2 0 0

Calf No.	Sex	Age at 400 lbs.	Age at 600 lbs.	Days 400-600 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. Per 100 lbs. Gain
							Hay:	Conc:	
108	-	---	---	---	---	---	---	---	---
114	M	166	285	119	194	1.63	2.66	4.83	470.89
128	-	---	---	---	---	---	---	---	---
135	M	146	251	105	194	1.85	2.33	4.24	412.89
150	M	165	270	105	200	1.90	2.27	4.17	405.65
163	F	160	272	112	196	1.75	2.47	4.53	440.49
169	M	152	257	105	188	1.79	2.43	4.42	430.92
186	M	186	305	119	194	1.63	2.69	4.87	475.70
192	F	167	286	119	204	1.71	2.60	4.72	460.11
138	M	173	271	98	186	1.90	2.32	4.22	411.90
168	F	225	365	140	208	1.49	2.87	4.96	490.89
Average:		171	285	114	---	1.74	2.52	4.55	444.38

Appendix Table 3 (Cont.)

B U L L N O . 1 9 9

Calf No.	Sex	Age at 400 lbs.	Age at 600 lbs.	Days 400-600 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. Per 100 lbs.Gain
							Hay:	Conc:	
102	M	165	284	119	192	1.61	2.70	4.94	480.75
119	M	195	335	140	196	1.40	3.11	5.52	542.12
126	F	188	300	112	196	1.75	2.46	4.53	439.58
134	F	174	279	105	200	1.90	2.24	4.12	400.36
146	M	176	288	112	194	1.73	2.45	4.54	440.33
164	M	184	310	126	202	1.60	2.73	4.94	482.42
175	F	191	331	140	188	1.34	3.09	5.64	549.64
187	-	---	---	---	---	---	---	---	---
188	-	---	---	---	---	---	---	---	---
172	M	181	293	112	200	1.79	2.47	4.49	437.38
112	M	183	302	119	194	1.63	2.66	4.75	465.19
Average:		182	302.4	120.6	---	1.64	2.66	4.83	470.86

Appendix Table 3 (Cont.)

B U L L N o . 2 0 7

Calf No.	Sex	Age at 400 lbs.	Age at 600 lbs.	Days 400-600 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. Per 100 lbs.Gain
							Hay:	Conc:	
106	M	154	245	91	198	2.18	2.05	3.67	359.23
121	M	175	301	126	200	1.59	2.60	4.90	473.08
131	-	---	---	---	---	---	---	---	---
137	F	221	361	140	204	1.46	2.98	5.45	530.39
153	F	184	310	126	184	1.46	2.96	5.47	530.57
156	M	170	282	112	174	1.55	2.84	5.06	496.73
166	M	200	298	98	200	2.04	2.07	3.86	373.61
183	M	210	308	98	186	1.90	2.30	4.19	408.40
196	F	183	281	98	200	2.04	2.06	3.84	371.84
155	M	173	285	112	198	1.77	2.47	4.50	438.37
129	M	193	298	105	204	1.94	2.24	4.09	398.54
Average:		186.3	297	110.6	---	1.79	2.46	4.50	438.08

Appendix Table 3 (Cont.)

B U L L N o . 2 0 5

Calf No.	Sex	Age at 400 lbs.	Age at 600 lbs.	Days 400-600 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. Per 100 lbs. Gain
							Hay:	Conc:	
101	M	205	331	126	200	1.59	2.71	4.94	481.19
115	M	183	295	112	186	1.66	2.64	4.83	470.12
127	-	---	---	---	---	---	---	---	---
139	M	212	324	112	200-	1.79	2.47	4.51	438.80
149	M	198	331	133	194	1.46	2.94	5.45	528.21
159	M	177	275	98	180	1.84	2.40	4.34	423.62
170	F	187	306	119	198	1.66	2.56	4.75	460.59
179	M	170	296	126	208	1.65	2.68	4.86	474.27
191	F	208	334	126	202	1.60	2.71	5.01	486.20
182	F	217	357	140	198	1.41	3.15	5.60	549.39
190	F	181	314	133	198	1.49	2.89	5.36	519.95
Average:		193.8	316.3	122.5	---	1.62	2.72	4.97	483.23

Appendix Table 3 (Cont.)

B U L L N o . 2 0 3

Calf No.	Sex	Age at 400 lbs.	Age at 600 lbs.	Days 400-600 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. Per 100 lbs. Gain
							Hay:	Conc:	
107	F	203	322	119	196	1.65	2.60	4.77	463.94
111	M	155	288	133	200	1.50	2.87	5.30	514.43
124	-	---	---	---	---	---	---	---	---
142	M	172	270	98	188	1.92	2.20	4.08	395.36
151	F	184	310	126	206	1.63	2.61	4.85	469.86
160	M	142	275	133	196	1.47	2.90	5.36	519.93
173	M	238	357	119	208	1.75	2.48	4.39	431.27
181	M	189	308	119	198	1.66	2.61	4.76	464.07
193	F	194	313	119	184	1.55	2.81	5.13	499.55
145	-	---	---	---	---	---	---	---	---
105	F	181	307	126	190	1.51	2.88	5.24	510.77
Average:		184	305.6	121	---	1.63	2.66	4.88	474.35

Appendix Table 3 (Cont.)

B U L L N o . 2 0 2

Calf No.	Sex	Age at 400 lbs.	Age at 600 lbs.	Days 400-600 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. Per 100 lbs. Gain
							Hay:	Conc:	
100	M	171	297	126	208	1.65	2.57	4.60	450.52
113	F	193	319	126	200	1.59	2.75	4.99	486.91
122	F	240	373	133	204	1.53	2.85	5.14	502.14
136	M	187	285	98	202	2.06	2.01	3.61	353.27
147	F	190	309	119	202	1.70	2.50	4.52	441.38
158	F	179	298	119	204	1.71	2.58	4.70	457.73
174	F	242	375	133	196	1.47	2.93	5.36	521.85
184	M	158	270	112	194	1.73	2.52	4.61	448.62
161	-	---	---	---	---	---	---	---	---
180	F	258	384	126	198	1.57	2.49	4.75	457.39
Average		202	323.3	121.3	---	1.67	2.58	4.70	457.76

Appendix Table 3 (Cont.)

B U L L N o . 2 0 4

Calf No.	Sex	Age at 400 lbs.	Age at 600 lbs.	Days 400-600 lbs.	Total Gain	Gain Per Day	Feed/lb. Gain		Lbs. T.D.N. Per 100 lbs.Gain
							Hay:	Conc:	
110	F	197	337	140	200	1.43	2.99	5.45	531.13
118	F	218	358	140	194	1.39	3.07	5.60	545.59
130	M	251	377	126	196	1.56	2.72	5.03	487.80
143	M	154	266	112	194	1.73	2.50	4.60	447.15
148	M	175	315	140	194	1.39	3.15	5.75	559.66
165	-	---	---	---	---	---	---	---	---
176	-	---	---	---	---	---	---	---	---
178	M	195	307	112	194	1.73	2.46	4.58	443.34
189	M	229	355	126	186	1.48	2.97	5.20	512.39
197	M	174	321	147	202	1.37	2.97	5.27	517.22
140	-	---	---	---	---	---	---	---	---
Average:		199	329.5	130.4	---	1.51	2.85	5.19	505.54

Appendix Table 3 (Cont.)

B U L L N o . 2 0 6

Calf No.	Sex	Age at 400 lbs.	Age at 600 lbs.	Days 400-600 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. Per 100 lbs. Gain
							Hay:	Conc:	
104	F	189	322	133	198	1.49	2.99	5.40	527.29
120	M	174	293	119	194	1.63	2.73	4.90	479.60
132	-	---	---	---	---	---	---	---	---
141	M	187	327	140	194	1.39	3.15	5.72	557.83
154	M	160	286	126	200	1.59	2.79	5.06	494.21
157	M	171	283	112	200	1.79	2.43	4.44	432.23
171	M	181	293	112	180	1.61	2.77	5.01	489.29
177	M	170	275	105	186	1.77	2.52	4.55	444.77
194	F	167	300	133	210	1.58	2.71	4.98	484.04
125	-	---	---	---	---	---	---	---	---
152	F	215	369	154	200	1.30	3.47	6.23	609.41
Average:		179.3	305.3	126	---	1.57	2.84	5.14	502.07

Appendix Table 3 (Cont.)

B U L L N o . 2 0 1

Calf No.	Sex	Age at 400 lbs.	Age at 600 lbs.	Days 400-600 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. Per 100 lbs. Gain
							Hay:	Conc:	
103	M	158	277	119	198	1.66	2.47	4.64	447.90
117	F	168	308	140	196	1.40	3.13	5.60	548.55
123	F	251	363	112	190	1.70	2.54	4.65	452.72
133	M	173	292	119	198	1.66	2.55	4.56	446.78
144	F	196	343	147	198	1.35	3.25	5.35	571.96
162	F	207	361	154	202	1.31	3.35	6.01	588.20
167	M	178	325	147	198	1.35	3.26	5.80	569.17
185	F	203	329	126	200	1.59	2.77	5.05	491.88
198	M	152	285	133	196	1.47	3.02	5.49	534.91
116	M	176	288	112	190	1.70	2.55	4.67	454.47
109	F	213	374	161	196	1.22	3.63	6.42	630.98
Average:		188.6	322.3	133.6	---	1.49	2.96	5.34	521.59

Appendix Table 4

B U L L N o . 2 0 0

Calf No.	Sex	Age at 600 lbs.	Age at 800 lbs.	Days 600-800 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain Hay:	Conc:	Lbs. T.D.N. Per 100 Lbs.Gain
108	-	---	---	---	---	---	---	---	---
114	M	285	376	91	214	2.35	2.66	3.88	404.50
128	-	---	---	---	---	---	---	---	---
135	M	251	342	91	208	2.29	2.66	3.95	409.77
150	M	270	382	112	214	1.91	3.24	4.76	495.59
163	F	272	398	126	218	1.73	3.54	5.24	543.69
169	M	257	376	119	214	1.80	3.44	5.05	525.51
186	M	305	445	140	208	1.49	4.12	5.63	599.80
192	F	286	405	119	182	1.53	4.09	5.97	622.61
138	M	271	383	112	230	2.05	3.03	4.43	461.45
168	F	365	477	112	194	1.73	3.56	5.24	544.77
AVERAGE:		285	398	114	---	1.88	3.37	4.91	511.97

Appendix Table 4 (Cont.)

B U L L N o . 1 9 9

Calf No.	Sex	Age at 600 lbs.	Age at 800 lbs.	Days 600-800 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. Per 100 lbs.Gain
							Hay:	Conc:	
102	M	284	389	105	208	1.98	3.07	4.55	471.72
119	M	335	440	105	204	1.94	3.14	4.53	474.38
126	F	300	433	133	212	1.59	3.90	5.71	594.66
134	F	279	405	126	202	1.60	3.83	5.62	584.53
146	M	288	393	105	206	1.96	3.04	4.53	468.63
164	M	310	429	119	186	1.56	3.96	5.79	603.65
175	F	331	485	154	200	1.30	4.78	6.97	727.18
187	-	---	---	---	---	---	---	---	---
188	-	---	---	---	---	---	---	---	---
172	M	293	419	126	212	1.68	3.67	5.36	558.91
112	M	302	400	98	198	2.02	3.01	4.47	463.66
AVERAGE:		302	421	119	---	1.74	3.60	5.28	549.70

Appendix Table 4 (Cont.)

B U L L N o . 2 0 7

Calf No.	Sex	Age at 600 lbs.	Age at 800 lbs.	Days 600-800 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. Per 100 Lbs.Gain
							Hay:	Conc:	
106	M	245	357	112	196	1.75	3.49	5.16	535.68
121	M	301	399	98	202	2.06	2.97	4.38	454.77
131	-	---	---	---	---	---	---	---	---
137	F	361	494	133	198	1.49	4.17	6.12	636.92
153	F	310	429	119	192	1.61	3.81	5.60	582.19
156	M	282	394	112	210	1.88	3.24	4.83	500.03
166	M	298	431	133	214	1.61	3.80	5.58	580.64
183	M	308	427	119	210	1.76	3.48	5.11	531.60
196	F	281	414	133	206	1.55	3.98	5.82	606.58
155	M	285	390	105	210	2.00	3.08	4.54	471.38
129	M	298	424	126	200	1.59	3.66	5.72	583.57
AVERAGE:		297	416	119	---	1.73	3.57	5.29	548.34

Appendix Table 4 (Cont.)

B U L L N o . 2 0 5

Calf No.	Sex	Age at 600 lbs.	Age at 800 lbs.	Days 600-800 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. Per 100 Lbs.Gain
							Hay:	Conc:	
101	M	331	457	126	220	1.75	3.59	5.16	540.56
115	M	295	400	105	200	1.90	3.27	4.78	498.22
127	-	---	---	---	---	---	---	---	---
139	M	324	443	119	198	1.66	3.71	5.46	567.56
149	M	331	443	112	224	2.00	3.07	4.55	471.73
159	M	275	394	119	208	1.75	3.45	5.15	533.48
170	F	306	418	112	202	1.80	3.43	4.91	515.44
179	M	296	401	105	214	2.04	3.05	4.47	465.20
191	F	334	460	126	198	1.57	3.88	5.74	595.83
182	F	357	490	133	216	1.62	3.81	5.62	583.80
190	F	314	454	140	196	1.40	4.32	6.43	666.08
AVERAGE:		316.3	436.0	119.7	---	1.75	3.56	5.23	543.79

Appendix Table 4 (Cont.)

B U L L N o . 2 0 3

Calf No.	Sex	Age at 600 lbs.	Age at 800 lbs.	Days 600-800 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. per 100 lbs.Gain
							Hay:	Conc:	
107	F	322	455	133	210	1.58	3.93	5.76	599.91
111	M	288	393	105	200	1.90	3.22	4.76	494.28
124	-	---	---	---	---	---	---	---	---
142	M	270	375	105	200	1.90	3.17	4.73	489.95
151	F	310	450	140	200	1.43	4.21	6.20	644.54
160	M	275	394	119	218	1.83	3.35	4.94	513.65
173	M	357	462	105	186	1.77	3.47	5.13	532.70
181	M	308	427	119	202	1.70	3.65	5.36	557.73
193	F	313	439	126	226	1.79	3.43	5.07	525.92
145	-	---	---	---	---	---	---	---	---
105	F	307	426	119	204	1.71	3.58	5.25	546.75
AVERAGE:		305.6	424.6	119.0	---	1.73	3.56	5.24	545.05

Appendix Table 4 (Cont.)

B U L L N o . 2 0 2

Calf No.	Sex	Age at 600 lbs.	Age at 800 lbs.	Days 600-800 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. Per 100 lbs.Gain
							Hay:	Conc:	
100	M	297	416	119	192	1.61	3.80	5.62	583.33
113	F	319	424	105	200	1.90	3.24	4.76	495.29
122	F	373	499	126	200	1.59	3.89	5.73	595.46
136	M	285	404	119	194	1.63	3.77	5.33	561.67
147	F	309	449	140	198	1.41	4.33	6.37	662.18
158	F	298	431	133	194	1.46	4.06	5.89	615.36
174	F	375	522	147	194	1.32	4.64	6.82	709.43
184	M	270	368	98	212	2.16	2.83	4.18	433.73
195	F	---	---	---	---	---	---	---	---
161	-	---	---	---	---	---	---	---	---
180	F	384	531	147	206	1.40	4.34	6.38	663.32
AVERAGE:		323.3	449.3	126.0	---	1.61	3.88	5.68	591.09

Appendix Table 4 (Cont.)

B U L L N o . 2 0 4

Calf No.	Sex	Age at 600 lbs.	Age at 800 lbs.	Days 600-800 Lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. per 100 lbs. Gain
							Hay:	Conc:	
110	F	337	463	126	202	1.60	3.82	5.64	585.73
118	F	358	498	140	210	1.50	4.01	5.79	606.03
130	M	377	503	126	204	1.62	3.80	5.56	579.27
143	M	266	371	105	200	1.90	3.18	4.73	490.42
148	M	315	448	133	220	1.65	3.67	5.28	552.96
165	-	---	---	---	---	---	---	---	---
176	-	---	---	---	---	---	---	---	---
178	M	307	426	119	206	1.73	3.55	5.21	542.24
189	M	355	481	126	218	1.73	3.54	5.03	528.83
197	M	321	440	119	202	1.70	3.68	5.34	557.96
140	-	---	---	---	---	---	---	---	---
AVERAGE:		329.5	453.8	124.3	---	1.68	3.66	5.32	555.43

Appendix Table 4 (Cont.)

B U L L N o . 2 0 6

Calf No.	Sex	Age at 600 lbs.	Age at 800 lbs.	Days 600-800 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. Per 100 lbs.Gain
							Hay:	Conc:	
104	F	322	497	175	210	1.20	5.02	7.35	765.21
120	M	293	405	112	202	1.80	3.40	5.01	521.22
132	-	---	---	---	---	---	---	---	---
141	M	327	446	119	216	1.82	3.41	5.00	520.64
154	M	286	426	140	206	1.47	4.20	6.18	642.75
157	M	283	395	112	200	1.79	3.42	5.04	524.02
171	M	293	405	112	204	1.82	3.34	4.95	513.58
177	M	275	373	98	226	2.31	2.67	3.94	409.06
194	F	300	440	140	198	1.41	4.33	6.32	658.94
125	-	---	---	---	---	---	---	---	---
152	F	369	481	112	194	1.73	3.57	5.26	546.53
Average:		305	387	124	---	1.71	3.71	5.45	566.88

Appendix Table 4 (Cont.)

B U L L N O . 2 0 1

Calf No.	Sex	Age at 600 lbs.	Age at 800 lbs.	Days 600-800 lbs.	Total Gain	Gain Per Day	Feed/lb. of Gain		Lbs. T.D.N. Per 100 lbs.Gain
							Hay:	Conc:	
103	M	277	389	112	208	1.86	3.35	4.90	510.55
117	F	308	420	112	196	1.75	3.50	5.13	534.20
123	F	363	510	147	210	1.43	4.31	6.35	659.55
133	M	292	404	112	204	1.82	3.33	4.90	509.90
144	F	343	504	161	198	1.23	4.92	6.76	719.20
162	F	361	487	126	200	1.59	3.87	5.64	587.86
167	M	325	458	133	220	1.65	3.78	5.46	570.88
185	F	329	441	112	206	1.84	3.32	4.90	508.66
198	M	285	390	105	198	1.89	3.20	4.77	493.97
116	M	288	400	112	210	1.88	3.26	4.77	496.70
109	F	374	507	133	202	1.52	4.00	5.68	597.69
AVERAGE:		322.3	446.4	124.1	---	1.68	3.71	5.39	562.65

Appendix Table 5

BULL No.200

BEEF CARCASS MEASUREMENTS

Calf No.:	108	114	128	135	150	163	169	186	192	138	168
Sex:	M	M	-	M	M	F	M	M	F	M	F
Carcass Grade	-	B	-	C	B	A	A	C	A	B	A
Warm Carcass Wt.	-	422	-	400	408	425	423	424	423	460	408
Cold Carcass Wt.	-	405	-	383	401	418	415	420	419	454	401
Wt. of Hind Quarters	-	206	-	195	202	211	205	201	209	223	196
Hind Leg Length, r.	-	23.2	-	22.5	22.9	24.3	23.2	23.0	22.9	22.7	23.4
" " " l.	-	23.4	-	23.1	22.9	24.3	23.1	23.0	23.1	22.7	23.1
Length of side, r.	-	43.1	-	43	44.5	44.7	43.3	43.6	43.3	43.9	44.0
" " " l.	-	43.0	-	43	44.9	45.0	43.7	43.4	43.0	44.1	43.5
Fat Distribution	-	3	-	2.5	2.5	4	3.5	3.5	2.5	3.5	3.5
Marbling	-	2.5	-	nil	2.0	3	3.0	3.5	3.5	3.5	5.0
Colour & Texture of Meat	-	3.0	-	3	2.0	4	4.0	3.5	3.5	4.5	5.0
Colour of Fat	-	4	-	3	2.5	4	3.0	4	3.5	4.0	3.5
Right Rib Section:											
Area of L.D. Muscle	-	65.13%	-	79.90%	62.09%	61.23%	65.15%	70.50%	56.41%	71.98%	71.41%
(in square inches)	-	(26.43)	-	(29.34)	(21.88)	(24.14)	(27.18)	(26.96)	(25.00)	(28.23)	(27.52)
Area of Fat	-	34.87%	-	20.10%	37.91%	38.77%	34.85%	29.50%	43.59%	28.02%	28.59%
(in square inches)	-	(14.15)	-	(7.38)	(13.36)	(15.28)	(14.54)	(11.28)	(19.32)	(10.99)	(11.02)

Appendix Table 5 (Cont.)

B U L L N o . 2 0 0

CALF NO.	REMARKS
108	-
114	None
128	-
135	Fat fairly well distributed, but lacking; rounds bare; good type; lack of cover lowers carcass to C grade.
150	Underfinished; lacks fleshing over loins and rounds.
163	None
169	None
186	None
192	Bare ends; loin not too strong; ribs and loin nicely covered.
138	None
168	Low A; good rib and loin; plain end cuts; very nice rib cut.

Appendix Table 5 (Cont.)

BULL No.199

BEEF CARCASS MEASUREMENTS

Calf No.:	102	119	126	134	146	164	175	187	188	172	112
Sex:	M	M	F	F	M	M	F	M	-	M	M
Carcass Grade	A	C	A	A	B	A	A	-	-	B	A
Warm Carcass Wt.	437	416	428	434	402	442	410	-	-	417	422
Cold Carcass Wt.	430	409	423	430	386	438	404	-	-	412	418
Wt.of Hind Quarters	212	204	210	222	196	218	203	-	-	209	205
Hind Leg Length, r.	23.1	24.1	23.1	22.5	22.4	23.4	23.2	-	-	23.2	22.8
" " " l.	23.2	24.6	23.3	22.8	23.0	23.4	23.1	-	-	23.5	23.1
Length of side, r.	42.8	43.2	44.3	43.5	43.0	43.4	43.5	-	-	43.4	42.7
" " " l.	42.8	43.5	43.8	43.4	42.7	43.7	43.7	-	-	43.4	43.0
Fat distribution	4.5	2	3.0	4.5	2.5	3	3.8	-	-	3	4
Marbling	3.5	2	3.5	4.0	2.0	3	4.5	-	-	2	2
Colour & Texture of Meat	5	3	4.0	5.0	3.5	3.5	5.0	-	-	2	3
Colour of Fat	4	2	3.5	4.3	3.5	3	3.5	-	-	3	3
Right Rib Section:											
Area of L.D. Muscle (in square inches)	70.88% (29.94)	77.31% (31.48)	62.07% (27.36)	58.12% (25.41)	66.37% (24.00)	68.07% (29.68)	69.70% (27.38)	- -	- -	68.59% (29.63)	73.94% (29.34)
Area of Fat (in square inches)	29.12% (12.30)	22.69% (9.24)	37.93% (16.72)	41.88% (18.31)	33.63% (12.16)	31.93% (13.92)	30.30% (11.90)	- -	- -	31.41% (13.57)	26.06% (10.34)

Appendix Table 5 (Cont.)

B U L L N o . 1 9 9

CALF NO.	REMARKS
102	None
119	A light cover; barish over loin, hip and ribs; only fat in regular pattern.
126	Hips full; a little weak in loin.
134	A very good carcass; a well rilled round and steak piece; very thick through lower rib and plate.
146	None
164	A full steer; minimum finish but cover uniformly laid on.
175	Low "A" carcass; lacking in steak-piece.
187	-
188	-
172	Texture of meat was course and meat had a darkish colour.
112	Excellent conformation; lack of finish.

Appendix Table 5 (Cont.)

BULL No.207

BEEF CARCASS MEASUREMENTS

Calf No.:	106	121	131	137	153	156	166	183	196	155	129
Sex:	M	M	-	F	F	M	M	M	F	M	M
Carcass Grade	A	A	-	C	B	A	B	A	B	A	B
Warm Carcass Wt.	441	430	-	416	424	430	445	428	427	432	430
Cold Carcass Wt.	437	424	-	411	418	425	438	422	422	425	422
Wt. of Hind Quarters	204-	206	-	205	206	212	217	207	206	214	205
Hind Leg Length, r.	23.1	23.1	-	23.0	23.1	23	24.0	22.8	23.9	23.0	23.2
" " " l.	23.0	23.2	-	23.1	23.9	23	23.9	22.8	24	23.8	23.5
Length of side, r.	42.3	42.6	-	45.1	43.4	43.5	43.6	42.8	43.5	42.3	44.5
" " " l.	42.5	42.5	-	45.5	43.2	43.5	43.6	42.7	43.5	42.4	44.2
Fat distribution	5	4	-	4	3.5	4	3	4	2.5	4	3
Marbling	3	5	-	2	3.5	4	1	4.5	2.5	4	3
Colour & Texture of Meat	4	4	-	3	4.0	5	3.5	5	3	4	3
Colour of Fat	5	4	-	4	4.0	5	3.5	4	3	4	2.5
Right Rib Section:											
Area of L.D. Muscle (in square inches)	60.69% (25.20)	59.31% (24.79)	-	73.76% (29.80)	65.51% (27.46)	69.42% (30.49)	74.68% (32.68)	68.31% (26.68)	68.44% (29.32)	59.23% (24.32)	64.13% (26.24)
Area of Fat (in square inches)	39.31% (16.32)	40.69% (17.01)	-	26.24% (10.60)	34.49% (14.46)	30.58% (13.43)	25.32% (11.08)	31.69% (12.38)	31.56% (13.52)	40.77% (16.75)	35.87% (14.68)

Appendix Table 5 (Cont.)

B U L L N o . 2 0 7

CALF NO.	REMARKS
106	None
121	None
131	-
137	None
153	None
156	None
166	Good fleshing and conformation; lacking finish.
183	None
196	Very hollow loin
155	Good colour
129	Conformation good; a weak finish.

Appendix Table 5 (Cont.)

BULL No.205

BEEF CARCASS MEASUREMENTS

Calf No.:	101	115	127	139	149	159	170	179	191	182	190
Sex:	M	M	F	M	M	M	F	M	F	F	F
Carcass Grade	B	C	-	B	B	B	B	B	A	B	B
Warm Carcass Wt.	413	428	-	419	439	434	418	404	412	432	433
Cold Carcass Wt.-	408	419	-	415	422	428	412	398	407	428	428
Wt.of Hind Quarters	205	211	-	208	217	218	216	197	210	221	220
Hind Leg Length, r.	23.2	23	-	23	22.7	23.1	23.1	23.3	23.0	23.0	23.4
" " " l.	23.7	23	-	22.8	22.7	23.5	23.0	23.4	23.4	23.1	23.6
Length of side, r.	43.5	43.7	-	42.3	43.2	43.2	43.9	42.7	42.7	43.0	42.4
" " " l.	43.0	42.9	-	42.9	43.2	43.2	43.3	42.6	43.0	42.9	42.2
Fat Distribution	3	2	-	2.5	3	3	3.0	3.5	4	2.5	3
Marbling	1.5	2	-	2.5	3	3	4.5	2.5	4	4.0	4
Colour & Texture of Meat	3	3	-	3	3	2	4.3	4	4	3.5	4
Colour of Fat	2.5	3	-	3	3	4	3.0	3	4	4	3.5
Right Rib Section:											
Area of L.D. Muscle (in square inches)	66.60% (27.12)	75.26% (30.36)	- -	62.39% (28.40)	69.59% (29.72)	65.6% (26.28)	66.40% (26.72)	60.86% (23.88)	58.42% (27.88)	54.01% (28.28)	46.06% (22.92)
Area of Fat (in square inches)	33.40% (13.60)	24.74% (9.98)	- -	37.61% (17.12)	30.41% (12.99)	34.4% (13.77)	33.60% (19.52)	39.14% (15.36)	41.58% (19.84)	45.99% (24.08)	53.94% (26.84)

Appendix Table 5 (Cont.)

B U L L N o . 2 0 5

CALF NO.	REMARKS
101	Light finish; off-colour; almost without marbling.
115	A full steer; lacking finish; a good eye but no marbling.
127	-
139	A beef of good conformation but a weak finish.
149	A top B carcass.
159	Rib-cut quite dark; very full rounds.
170	Plain shoulders and slightly down in loin; good buttocks.
179	Poor conformation of loin, steak piece and round.
191	Evenly covered; well fatted; good conformation; a choice heifer.
182	Overfinished natural pattern, especially hooks and tail-head; shallow loins; hip conformation weak.
190	Bare hips; excessive fat over tail head, hooks and shoulders; loin and hip conformation poor.

Appendix Table 5 (Cont.)

BULL No.203

BEEF CARCASS MEASUREMENTS

Calf No.:	107	111	124	142	151	160	173	181	193	145	105
Sex:	F	M	F	M	F	M	M	M	F	-	F
Carcass Grade	B	B	-	C	A	C	D_1	B	A	-	A
Warm Carcass Wt.	450	402	-	396	434	400	386	429	440	-	412
Cold Carcass Wt.	442	395	-	392	427	394	380	420	436	-	405
Wt.of Hind Quarters	221	194	-	198	211	196	192	208	216	-	203
Hind Leg Length, r.	23.4	23.4	-	23.4	23.3	24.1	23.8	24.2	22.7	-	22.3
" " " l.	23.6	23.7	-	23.6	23.1	24.3	23.6	24.7	23.1	-	22.2
Length of side, r.	43.4	42.6	-	42.7	42.3	45.0	44.2	44.2	43.1	-	41.9
" " " l.	43	42.8	-	42.7	42.2	45.1	44.1	44.0	43.1	-	41.5
Fat distribution	2.5	3.0	-	3.0	4	2.0	4	3	4	-	3
Marbling	4	1.5	-	1.5	4	2.0	0	3	4	-	3
Colour and Texture of Meat	4	2	-	2.5	3	4.0	2	3.5	4	-	3
Colour of Fat	3.5	3	-	2.5	3.5	2.5	2	3	4	-	3
Right Rib Section:											
Area of L.D. Muscle (in square inches)	58.04% (25.40)	62.21% (24.56)	-	75.43% (26.55)	50.00% (25.44)	72.05% (23.66)	77.18% (26.92)	62.61% (25.32)	56.80% (25.88)	-	57.41% (22.04)
Area of Fat (in square inches)	41.96% (18.36)	37.79% (14.92)	-	24.57% (8.65)	50.00% (25.44)	27.95% (9.18)	22.82% (7.96)	37.39% (15.12)	43.20% (19.68)	-	42.59% (16.35)

Appendix Table 5 (Cont.)

BULL No. 203

CALF NO.	REMARKS
107	Bare on both ends; fair cover over loin and rib; a typical heifer loin and hip.
111	Shallow front; thin over shoulder.
124	-
142	Good conformation; bare over shoulders; fat lacks brightness.
151	None
160	Long, rangy type steer.
173	None
181	None
193	A good heifer; slightly weak loins, but strong enough to make the grade.
145	-
105	None

Appendix Table 5 (Cont.)

BULL No.202

BEEF CARCASS MEASUREMENTS

Calf No.:	100	113	122	136	147	158	174	184	195	161	180
Sex:	M	F	F	M	F	F	F	M	F	M	F
Carcass Grade	B	A	A	B	B	B	B	A	A	-	B
Warm Carcass Wt.	418	419	420	428	418	428	421	430	408	-	438
Cold Carcass Wt.	412	413	414	420	414	419	419	422	404	-	430
Wt. of Hind Quarters	201	212	206	212	204	217	213	210	201	-	217
Hind Leg Length, r.	23.1	23.1	23.5	23.3	22.4	23.3	23.4	24.1	23.0	-	22.4
" " " l.	23.4	23.2	23.7	23.1	22.5	23.4	23.1	24.1	22.7	-	22.3
Length of side, r.	43.5	42.7	42.8	43.4	43.9	42	43.0	43.3	41.8	-	43.2
" " " l.	43.7	42.5	42.9	43.2	43.9	42.4	42.6	43.2	41.5	-	43.1
Fat distribution	3.0	3.5	3.5	2.5	3	3	2.5	3	3	-	3.5
Marbling	4.0	4	3.8	2.5	3	4	3	3	3	-	4.7
Colour & Texture of Meat	4.0	4	3.9	3.0	4	4	3	4	3	-	5.0
Colour of Fat	3.5	3.5	3.5	2.5	4	4	3	3	3	-	4.2
Right Rib Section:											
Area of L.D. Muscle (in square inches)	63.82% (25.61)	55.31% (26.44)	53.71% (25.23)	64.26% (27.18)	69.06% (29.28)	52.30% (22.76)	53.72% (25.26)	66.88% (25.56)	55.68% (26.82)	- -	57.08% (24.51)
Area of Fat (in square inches)	36.18% (14.52)	44.69% (21.36)	46.29% (21.74)	35.74% (15.12)	30.94% (13.12)	47.70% (20.76)	46.28% (21.76)	32.12% (12.66)	44.32% (21.35)	- -	42.92% (18.43)

Appendix Table 5 (Cont.)

B U L L N o . 2 0 2

CALF NO.	REMARKS
100	Good formation; lacks a little over loin; bare over shoulder, particularly bare over point of shoulder
113	Formation only fair; good cover.
122	Poor rounds and loin; a low A carcass
136	A good full steer, but lacking finish
147	none
158	Fat cover good; a little excessive fat on ribs; conformation of loin and hip weak
174	Typical B heifer; weak conformation of hind quarters; fairly well covered.
184	None
195	Shipped before reached market weight; information not used.
161	-
180	Good plump carcass; lacking fleshing, noticably in loin

Appendix Table 5 (Cont.)

BULL No.204

BEEF CARCASS MEASUREMENTS

Calf No.:	110	118	130	143	148	165	176	178	189	197	140
Sex:	F	F	M	M	M	-	F	M	M	M	F
Carcass Grade	A	A	A	A	A	-	-	B	B	A	-
Warm Carcass Wt.	430	451	432	432	438	-	-	422	429	430	-
Cold Carcass Wt.	424	445	428	425	431	-	-	418	423	423	-
Wt.of Hind Quarters	212	219	210	212	210	-	-	207	207	201	-
Hind Leg Length, r.	22.2	23.1	22.4	22.6	22.9	-	-	23.2	23.1	22.6	-
" " " l.	22.4	23.3	22.1	22.8	23.2	-	-	23.3	23.1	23.1	-
Length of side, r.	44.2	42.9	42.5	43.2	42.6	-	-	44	42.5	42.0	-
" " " l.	43.5	42.6	42.1	43.2	42.8	-	-	43.8	42.7	42.1	-
Fat distribution	4.1	4.5	4	4	4	-	-	3	3	3	-
Marbling	4.2	4.5	4	3	4	-	-	2.5	3	3.5	-
Colour and Texture of Meat	4.5	4.4	4	3	4	-	-	2.5	4	4	-
Colour of Fat	4.2	4.2	4	4	4	-	-	3	3	3	-
Right Rib Section:											
Area of L.D. Muscle	62.90%	51.99%	62.55%	66.59%	52.41%	-	-	66.06%	65.65%	68.54%	-
(in square inches)	(29.20)	(25.96)	(27.12)	(29.34)	(24.40)	-	-	(27.72)	(27.58)	(28.35)	-
Area of Fat	37.10%	48.01%	37.45%	33.41%	47.59%	-	-	33.94%	34.35%	31.46%	-
(in square inches)	(17.23)	(23.97)	(16.24)	(14.72)	(22.16)	-	-	(14.24)	(14.43)	(13.01)	-

Appendix Table 5 (Cont.)

B U L L N o . 2 0 4

CALF NO.	REMARKS
110	Good A carcass
118	Short, blocky carcass; very fat over rib, almost wasty.
130	None
143	Dark cut; full rounds
148	None
165	-
176	-
178	A beef of fair finish but poor hind quarter conformation; loin particularly hollow.
189	Distribution of fat good but lacking quantity.
197	None
140	-

Appendix Table 5 (Cont.)

BULL No.206

BEEF CARCASS MEASUREMENTS

Calf No.:	104	120	132	141	154	157	171	177	194	125	152
Sex:	F	M	-	M	M	M	M	M	F	-	F
Carcass Grade	A	A	-	B	B	A	A	A	B	-	B
Warm Carcass Wt.	450	433	-	-	427	429	426	440	433	-	423
Cold Carcass Wt.	445	428	-	-	422	421	420	432.5	425	-	448
Wt.of Hind Quarters	230	209	-	-	208	210	208	218.5	210	-	211
Hind Leg Length, r.	23	22.6	-	-	23.2	23.4	23.1	23.2	23.5	-	22.6
" " " l.	23.3	22.8	-	-	23.1	23.4	23.1	23.9	23.6	-	23.0
Length of side, r.	44.1	44	-	-	43.0	42.6	43.5	43.7	44.2	-	42.5
" " " l.	43.7	43.6	-	-	43.5	43.3	43.7	43.8	44.1	-	42.9
Fat distribution	3.5	3	-	-	3	4	4.5	3	3	-	3
Marbling	4.0	4	-	-	2	4	4.5	3	3.5	-	4
Colour & Texture of Meat	4.1	4	-	-	3	4	4.5	3	3	-	3
Colour of Fat	4.0	3	-	-	3	4.5	4.0	5	3.5	-	4
Right Rib Section:											
Area of L.D. Muscle	66.49%	66.81%	-	-	69.75%	59.89%	62.05%	69.97%	59.78%	-	41.34%
(in square inches)	(31.77)	(29.05)	-	-	(30.05)	(25.92)	(26.77)	(28.96)	(27.76)	-	(22.04)
Area of Fat	33.51%	33.19%	-	-	30.25%	40.11%	37.95%	30.03%	40.22%	-	58.66%
(in square inches)	(16.01)	(14.43)	-	-	(13.03)	(17.36)	(16.37)	(12.43)	(18.68)	-	(31.28)

Appendix Table 5 (Cont.)

B U L L N o . 2 0 6

CALF NO.	REMARKS
104	Animal is lacking some in the rounds.
120	None
132	-
141	Carcass information not received from graders.
154	None
157	Good carcass
171	None
177	Animal is bare on both ends.
194	Bare on shoulders and hips, weak conformation of hip and loin.
125	-
152	Excessive fat; feathery intramuscular fat; bare end; poor loins.

Appendix Table 5 (Cont.)

BULL No.201

BEEF CARCASS MEASUREMENTS

Calf No.:	103	117	123	133	144	162	167	185	198	116	109
Sex:	M	F	F	M	F	F	M	F	M	M	F
Carcass Grade	A	A	B	A	A	A	A	B	A	B	A
Warm Carcass Wt.	-	-	418	421	441	437	436	435	430	433	441
Cold Carcass Wt.	-	-	415	417	435	432	427	430	422	417	436
Wt.of Hind Quarters	-	-	204	208	216	216	209	217	214	219	221
Hind Leg Length, r.	-	-	23.1	22.4	23.1	23.2	23.5	22.9	23.8	23.9	23.0
" " " l.	-	-	23.1	22.7	23.2	23.4	23.4	23.2	23.8	24.2	23.2
Length of side, r.	-	-	42.5	43.4	42.3	42.3	43.1	43.0	42.0	42.7	43.3
" " " l.	-	-	42.8	43.1	42.5	42.3	42.8	43.0	42.5	42.9	43.3
Fat distribution	-	-	2.5	3.5	4.0	3.0	4	3	4	4	4.0
Marbling	-	-	3.0	3.0	4.0	3.5	3	4	3	4	4.0
Colour & Texture of Meat	-	-	2.5	4.0	4.0	4.0	3	4	4	5	4.0
Colour of Fat	-	-	3.0	3.5	3.5	3.0	3	4	4	4	3.8
Right Rib Section:											
Area of L.D. Muscle	-	-	62.92%	56.83%	53.06%	54.67%	55.17%	53.36%	65.13%	69.13%	59.27%
(in square inches)	-	-	(24.54)	(27.64)	(25.316)	(25.45)	(26.04)	(23.52)	(28.37)	(27.30)	(29.03)
Area of Fat	-	-	37.08%	43.17%	46.94%	45.33%	44.83%	46.64%	34.87%	30.87%	40.73%
(in square inches)	-	-	(14.46)	(20.99)	(22.40)	(21.10)	(21.16)	(20.56)	(15.19)	(12.19)	(19.95)

Appendix Table 5 (Cont.)

B U L L N o . 2 0 1

CALF NO.	REMARKS
103	Carcass information not received from graders.
117	Carcass information not received from graders.
123	A good heifer; slight weakness in loin and general confirmation; front quarters slightly bare.
133	None
144	A medium A carcass.
162	Slightly bare on both ends.
167	None
185	Poor loin conformation
198	None
116	None
109	Good A carcass.

BIBLIOGRAPHY

Ashton, G.C., H.L. Lucas, Jr., and F.W. Sherwood. 1955. Control of the error variance in swine feeding trials. I By covariance adjustment for pre-experimental measures. Jour. Anim. Sci. 14 : 1174. (Abstract)

Ashton, G.C., H.L. Lucas, Jr., and F.W. Sherwood. 1955. Control of the error variance in swine feeding trials. II By blocking and selection with respect to litter, sex and breeding. Jour. Anim. Sci. 14 : 1175. (Abstract)

Ashton, G.C., H.L. Lucas, Jr., and F.W. Sherwood. 1955. Control of the error variance in swine feeding trials. III By control of experimental conditions. Jour. Anim. Sci. 14 : 1175. (Abstract)

Baird, D.M., A.V. Nalbandov, and H.W. Norton. 1952. Some physiological causes of genetically different rates of growth in swine. Jour. Anim. Sci. 11 : 292.

Baker, M.L., et al. 1943. The relative importance of heredity and environment in growth of pigs at different ages. Journ. Anim. Sci. 2 : 1.

Baker, J.P., R.W. Colby, and C.M. Lyman. 1951. The relationship of feed efficiency to digestion rates of beef cattle. Journ. Anim. Sci. 10 : 726.

Bennett, J.A., and D.J. Matthews. 1955. Performance Testing studies with beef cattle. Agr. Exp. Sta., Utah State Agricultural College, Logan, Utah. Bul. 377.

Black, W.H. and Bradford Knapp, Jr. 1936. A method of measuring performance in beef cattle. Proc. of the American Society of Animal Production. pp. 73-77.

Black, W.H., et al. 1938. Correlation of body measurements of slaughter steers with rate and efficiency of gain and with certain carcass characteristics. Jour. Agr. Res. 56 : 465.

Bloom, P.E., 1953. Analysis of beef cattle production testing in Kittitas County, Washington. Am. Soc. Anim. Prod. Proc., Western Section, (4) II, 1-8.

Blunn, C.T., et al. 1953. Heritability of gain in different growth periods of swine. Jour. Anim. Sci. 12 : 1.

Bogart, R. and R.L. Blackwell. 1950. More beef with less feed. Oregon Agr. Exp. Sta. Bul. 488.

Bogart, R. and J.T. Elings. 1953. Production testing of beef cattle. Oregon State College, Corvallis, Extension Bul. 746.

Bogart, R., G.E. Nelms, R.W. Mason, et al. 1955. Body measurements, scores, gains, and feed efficiency of growing beef cattle. Jour. Anim. Sci. 14 : 1175-1176. (Abstract)

Botkin, M.P. and J.A. Whatley, Jr. 1953. Repeatability of production in range beef cows. Jour. Anim. Sci. 12 : 3.

Botkin, M.P. 1955. Selection for efficiency of gain in lambs. Jour. Anim. Sci. 14 : 1176. (Abstract)

Brody, S. 1945. Bioenergetics and Growth. Reinhold Publishing Corp. New York.

Buiatti, P.G. 1954. The heritability of live weight and height at withers and the correlation between them in Chiana Heifers. Riv. Zootec. 27 : 59-63. (Abstract)

Burgess, J.B., et al. 1954. Weaning weights of Hereford calves as affected by inbreeding, Sex and Age. Jour. Anim. Sci. 13 : 4.

Burris, M.J., and C.T. Blunn. 1952. Some factors affecting gestation length and birth weight of beef cattle. Jour. Anim. Sci. 11 : 1.

Burris, M.J., R. Bogart, A.W. Oliver, et al. 1954. Rate and Efficiency of gains in beef cattle. I. The response to injected testosterone. Tech. Bul. 31. Agr. Exp. Sta., Oregon State College Corvallis.

Burris, M.J., and C.A. Baugus. 1955. Milk consumption and growth of suckling lambs. Jour. Anim. Sci. 14 : 1.

Cartwright, T.C. and B.L. Warwick. 1955. The relationship between birth-weight, weaning weight and feedlot gain in beef cattle. Jour. Anim. Sci. 14 : 4 : p. 1178. (Abstract).

Commonwealth Agricultural Bureaux. 1954. C.A.B. report, Twenty-Fifth Annual Report of the Executive Council, 1953-1954. P. 30, top of page, under: 127 "Progeny Testing". London: Her Majesty's Stationary Office.

Conner, A.B. 1923. The interpretation of correlation data. Texas Agric. Expt. Sta. Bul. 310: 1.

Cook, A.C., M.L. Kohli, and W.M. Dawson. 1951. Relationship of five body measurements to slaughter grade, carcass grade and dressing percentage in Milking. Shorthorn steers. Jour. Anim. Sci. 10 : 386.

Dahmen, J.J. and R. Bogart. 1952. Some factors affecting rate and economy of gains in beef cattle. Agr. Exp. Sta., Oregon State College, Corvallis. Tech. Bul. 26.

Dawson, W.M., R.W. Phillips, and W.H. Black. 1947. Birth weight as a criterion of selection in beef cattle. Jour. Anim.Sci. 6 :247

Dawson, W.M., F.S. Yao, and A. C. Cook. 1955. Heritability of growth beef characters and body measurements in milking Shorthorn Steers. Jour. Anim. Sci. 14 : 1.

Dickerson, G.E. 1947. Composition of hog carcasses as influenced by heritable differences in rate and economy of gain. Iowa Agr. Expt. Sta. Res. Bul. 354 : 492.

Doornenbal, H. and A.J. Wood. 1952-1953. Beef bull research project, 1952-53. Dept. Anim. Husb., Faculty of Agric., The University of British Columbia. A mimeographed report.

Durham, R.M. and J.H. Knox. 1953. Correlations between grades and gains of Hereford cattle at different stages of growth and between grades at different times. Jour. Anim. Sci. 12:771-4,N.

Fine, N.C. and L.M. Winters. 1953. Selection for an increase in growth rate and market score in two inbred lines of swine. Jour. Anim. Sci. 12 : 2.

Flower, A.E., S. Fred, et al. 1954. Studies on gains of limited-fed steer calves and their subsequent range and full-fed gains. Western Section American Soc. Anim. Prod., Vol. 4 P XV-4.

Galgan, M.W., M.E. Ensminger, and D.E. Foster. 1955. 1954-1955 Production testing results with beef calves. Washington Agric. Exp. Stations Inst. Agric. Sciences, State College of Wash., Stations Circ. 264, April.

Gifford, W. 1949. Importance of high milk production in beef cows overestimated. Jour. Anim. Sci. 8 : 605-606.

Gifford, W. 1953. Records of Performance tests for cattle in breeding herds. Milk production of dams and growth of calves. University of Arkansas College of Agriculture, Fayetteville, Arkansas. Bul. 531, Feb.

Goulden, C.H. 1952. Methods of statistical analysis. John Wiley and Sons, Inc., New York. 2nd Ed.

Green, W.W. and J. Buric. 1953. Comparative performance of beef calves weaned at 90 to 180 days of age. Jour. Anim. Sci. 12 : 3.

Green, W.W. 1954. Relationships of measurements of live animals to weights of grouped significant wholesale cuts and dressing percent of beef steers. Jour. Anim. Sci. 13 : 1.

Gregory, K.E., C.T. Blunn, and M.L. Baker. 1950. A study of some of the factors influencing the birth and weaning weights of beef calves. Jour. Anim. Sci. 9 : 338.

Grizzle, J.E. and C.M. Kincaid. 1954. The relationship between body weight, daily gain, and efficiency of feed utilization in beef cattle. Jour. Anim Sci. 13 : 4 : 958. (Abstract).

Guilbert, H.R. and P.W. Gregory. 1944. Feed utilization tests with cattle. Jour. Anim.Sci. 3: 143.

Guilbert, H.R. and G.H. Hart. 1944. Feed utilization tests with cattle. Jour. Anim. Sci. 3 : 143.

Guilbert, H.R. and P.W. Gregory. 1952. Some features of growth and development of Hereford cattle. Jour. Anim. Sci. 11 : 1 : 3.

Hankins, O.G. and H.W. Titus. 1939. Growth, fattening and meat production. Food and Life, Year Book of Agriculture. Washington Government Printing Office.

Hazel, L.N., et al. 1943. Genetic and environmental correlations between the growth rates of pigs at different ages. Jour. Anim Sci. 2 : 118.

Hazel, L.N. 1946. Heritability of type and condition in range rambouillet lambs as evaluated by scoring. Jour. Anim. Sci. February.

Henderson, C.R. 1953. Estimation of variance and covariance components. Biometrics. 9 : 226.

Hetzer, H.O., et al. 1944. Heritability of type in Poland China swine as evaluated by scoring. Jour. Anim. Sci. 3 : 390.

Hitchcock, G.H., and W.A. Sawyer, et al. 1955. Rate and efficiency of gains in beef cattle. III Factors affecting weight and effectiveness of selection for gains in weight. Agr. Expt. Sta., Oregon State College, Tech. Bul. No. 34.

Hutt, F.B. 1951. Progeny tests and Warwick's tables. Bibliog. Jour. Heredity, 42 : 266. S '51.

Johnson, L.P.V. 1950. Applied Biometrics. Burgess Publishing Co., Minneapolis 15, Minnesota.

Kempthorne, O. and O.B. Tandon. 1953. The estimation of heritability by regression of offspring on parent. Biometrics. The Biometric Society, March, 9 : 1.

Kidwell, J.F. 1951. Number of progeny required to test a male for heterozygosity for a recessive autosomal gene. Bibliog. Jour. Heredity 42: 215-216.

Kidwell, J.F. 1952. Genetic investigation of allometric growth in Hereford cattle. Genetics 37 : 158-174, March.

Kidwell, J.F. 1953. Some growth relations in range Hereford cattle. Western Sect. Amer. Soc. of Anim. Prod. 4 : I : 1.

Kidwell, J.F. 1954. Some growth relations in range cattle. Jour. Anim. Sci. 13 : 1.

Kidwell, J.F. 1955. A study of the relation between body conformation and carcass quality in fat calves. Jour. Anim. Sci. 14:1:233.

Kincaid, C.M., R.C. Carter, and J.S. Copenhaver. 1952. Heritability of rate of gain from progeny tests with beef cattle. Jour. Anim. Sci. 11 : 741. (Abstract).

Kincaid, C.M. and R.C. Carter. 1955. Estimates of Heritability of rate of gain in beef cattle. Jour. Anim. Sci. 14 : 4 : 1185. (Abstract).

Kleiber, M. 1936. Problems involved in breeding for efficiency of food utilization. Amer. Soc. Anim. Prod. Proc. 247-258.

Klosterman, E.W., L.E. Kunkle, P. Gerlaugh, and V.R. Cahill. 1954. The effect of age of castration upon rate and economy of gain and carcass quality of beef calves. Jour. Anim. Sci. 13 : 4 : 817, November.

Knapp, B., Jr., et al. 1941[a]. Record of performance in Hereford cattle. Montana Agr. Exp. St. Bul. 397.

Knapp, B., Jr. and W.H. Black. 1941[b]. Factors influencing rate of gain of beef calves during the suckling period. Jour. Agr. Research. 63 : 249-254.

Knapp, B., Jr. and Phillips, et al. 1942[a]. Length of feeding period and number of animals required to measure economy of gain in progeny tests of beef cattle. Jour. Anim. Sci. 1 : 285-292.

Knapp, B., Jr., A.L. Baker, J.R. Quesenberry and R.T. Clark. 1942[b]. Growth and production factors in range cattle. Montana State College Agricultural Exp. Sta. Bul. 400.

Knapp, B.., Jr. and Baker, A.L. 1944. Correlation between ratio and efficiency of gain in steers. Jour. Anim. Sci. 3 : 3.

Knapp, B. and W. Nordskog. 1946[a]. Heritability of growth and efficiency in beef cattle. Jour. Anim. Sci. 5: 62-70.

Knapp, B. and W. Nordskog. 1946[b]. Heritability of animal scores, grades and certain carcass characteristics in beef cattle. Jour. Anim. Sci. 5 : 194-199.

Knapp, B. and R.T. Clark. 1947. Genetic and environmental correlations between growth rates of beef cattle at different ages. Jour. Anim. Sci. 6 : 174-181.

Knapp, B., Jr. and R.T. Clark. 1950. Revised estimates of heritability of economic characteristics in beef cattle. Jour. Anim. Sci. 9 : 582-587.

Knapp, B., Jr. and R.T. Clark. 1951. Genetic and environmental correlations between weaning scores and subsequent gains in the feedlot with record of performance steers. Jour. Anim. Sci. 10 (2) : 365-370.

Koch, R.C. 1956. Swing of the pendulum. The Farm Quarterly, winter, 1956.

Koch, R.M. 1951. Size of calves at weaning as a permanent characteristic of range Hereford cows. Jour. Anim Sci. 10 : 3 : 768.

Koch, R.M. and R.T. Clark, 1955. Genetic and environmental relationships among economic characters in beef cattle. I Correlations among paternal and maternal half-sibs. Jour. Anim. Sci. 14 : 3, August.

Koch, R.M. and R. T. Clark, 1955. Genetic and environmental relationships among economic characters in beef cattle. II Correlations between offspring and dam and offspring and sire. Jour. Anim. Sci. 14 : 3, August.

Koch, R.M. and R.T. Clark, 1955. Genetic and environmental relationships among economic characters in beef cattle. III Evaluating maternal environment. Jour. Anim. Sci. 14 : 4 : 979-996.

Koch, R.M. and R.T. Clark. 1955. Influence of sex, season of birth and age of dam on economic traits in range beef cattle. Jour. Anim. Sci. 14 : 2.

Koch, R.M., Schleicher, E.W. and V.H. Arthaud. 1955. Weight changes in beef calves following birth. Jour. Anim. Sci. 14 : 3.

Koger, M. and J.H. Knox. 1945. The effect of sex on weaning weight of range calves. Jour. Anim. Sci. 4 : 1.

Koger, M. J.H. Knox. 1947. The repeatability of yearly production of range Hereford cows. Jour. Anim. Sci. 6 : 461.

Koger, M. and J.H. Knox. 1951. The correlation between gains made at different periods by cattle. Jour. Anim. Sci. 10 : 760.

Koger, M. and J.H. Knox. 1952. Heritability of grade and type in range beef cattle. Jour. Anim. Sci. 11 : 361-369.

Kohli, M.I., A.C. Cook, and W.M. Dawson. 1951. Relationship between some body measurements and certain performance characteristics in milking Shorthorn steers. Jour. Anim. Sci. 10 : 352.

Kohli, M.L., A.C. Cook, and W.M. Dawson. 1952. Inheritance of growth rate and efficiency of gain in milking Shorthorn steers. Jour. Heredity. 43 : 249-252.

Kunkel, H.O., R.W. Colby, and C.M. Lyman. 1953. The relationship of serum protein-bound iodine levels to rates of gain in beef cattle. Jour. Anim. Sci. 12 : 1 : 3-9.

Lambert, W.V., et al. 1936. The role of nutrition in genetic research. Amer. Soc. Anim. Prod. p.236-243.

Lush, J.L. 1940. Intra-sire correlations of regression of offspring on dam as a method of estimating heritability of characteristics. Amer. Soc. Anim. Prod. Proc. 293-301.

Lush, J.L. 1945. Animal Breeding Plans. 3rd edition. Iowa State College Press.

Mason, I.L. 1951. Performance recording in beef cattle. Animal Breeding Abstract. 19 : 1-24.

Nelms, G.C. and R. Bogart. 1955. Some factors affecting feed utilization in growing beef cattle. Jour. Anim. Sci. 14 : 4 : 970-978.

Nelms, G.E. and R. Bogart. 1955. The effect of birth weight, age of dam and time of birth on suckling gains of beef calves. Jour. Anim. Sci., November, 14 : 4 : 1187. (Abstract).

Norskog, A.W. 1944. Hereditary and environmental factors effecting growth rate in swine. Jour. Anim. Sci. 3 : 257.

Patterson, R.E., et al. 1949. Performance testing and progeny testing of beef breeding stock as an aid to selection. Jour. Anim. Sci. 8 : 608. (Abstract.

Patterson, R.E., T.C. Cartwright, J.H. Jones, and J.J. Bayles. 1955. Performance testing of beef breeding stock. Jour. Anim. Sci. 14 : 4 : 1034-1041.

Pierce, C.D., H.G. Avery, M. Burris, and R. Bogart. 1954. Rate and efficiency of gains in beef cattle. II. Some factors affecting performance testing. Agric. Exp. Sta., Oregon State College, Tech. Bul. 33, July.

Rice, F.J., et al. 1954. Length of gestation in Hereford cows and its relation to performance. Jour. Anim. Sci. 13 : 4: 961. (Abstract).

Rice, V.A. and F.N. Andrews. 1942. Breeding and improvement of farm animals. 4th edition. McGraw-Hill Book Co.,Inc., New York.

Rife, D.C. 1951. Method for testing two-factor inheritance. Jour. Heredity. 42 : 162.

Riley, D.N., 1953. Rate and efficiency of gain of pure-bred beef bulls. Essay submitted in partial fulfillment of the requirements for B.S.A. degree in the Faculty of Agriculture, University of British Columbia, B.C.

Robertson, A. 1952. Effect of inbreeding on the variation due to recessive genes. Genetics 37 : 189-207.

Rollins, W.C. and H.R. Guilbert. 1954. Factors effecting the growth of beef calves during the suckling period. Jour. Anim. Sci. 13 : 2.

Roubicek,C.B., N.W. Hilston, and S.S. Wheeler. 1951. Progeny Studies with Hereford and Shorthorn cattle. Wyoming Agric. Exp. Sta., Laramie; Bul. 307, July.

Shelby, C.E., R.T. Clark, et al. 1954. Heritability of some pre- and post-slaughter characteristics in beef cattle. Jour. Anim. Sci. 13 : 4 : 962. (Abstract).

Shelby, C.E., R.T. Clark, and R.R. Woodward. 1955. The heritability of some economic characteristics of beef cattle. Jour. Anim. Sci. 14 : 2.

Snedecor, G.W. 1948. Statistical Methods. Iowa State College, Ames, 485 pp.

Spilma and Lang. 1924. The law of diminishing returns. 178 pp. illus. Chicago.

Stonaker, H.H., et al. 1950. Beef breeding research in Colorado. Progress report mimeo, July.

Stonaker, H.H., et al. 1952. Feedlot and carcass characteristics of individually fed comprest and conventional types Hereford steers. Jour. Anim. Sci. 11 : 1.

Tyler, W.J., et al. 1948. The heritability of body size of Holstein, Friesian and Aysnire cattle. Jour. Anim. Sci. 7 : 516. (Abstract).

Warwick, B.L., T.C. Cartwright, and M.W. Hazen. 1954. Beef cattle performance at Bluebonnet Farm. I. Evaluation tests for gaining ability. Texas Agric. Exp. Sta. Bul. 790.

Warwick, B.L. and T.C. Cartwright. 1955. Heritability of rate of gain in young growing beef cattle. Jour. Anim. Sci. 14 : 2.

Went, F.W. 1953. Gene action in relation to growth and development; phenotypic variability. Nat. Acad. Sci. Proc. 39 : 839-848.

White, F.E. and W.W. Green. 1952. Relationship of measurements of live animals to weights of wholesale cuts of beef. Jour. Anim. Sci. 11 : 2.

Whiting, F. 1955. Steer feeding report. Canadian Cattlemen, January.

Willey, N.B., O.D. Butler, J.K. Riggs, J.H. Jones, et al. 1951. The influence of type on feedlot performance and killing qualities of Hereford steers. Jour. Anim. Sci. 10 : 195.

Williams, L. 1956. Personal correspondence. Canyon City, Oregon, U.S.A.

Wilson, F.S., et al. 1954. Genetic studies of steer progeny groups slaughtered following three successive feeding treatments. Jour. Anim. Sci. 13 : 4 : 965. (Abstract).

Winsor and Clark. 1940. A statistical study of variation in the catch of plankton nets. Jour. Marine Res. 3 : 1-34.

Winters, L.M. and H. McMahon. 1933. Efficiency variations in steers. Minnesota Agric. Exp. Sta. Tech. Bul. 94 : 1-28.

Woodward, R.R. and R.T. Clark. 1950. The repeatability of performance of several Hereford sires as measured by progeny records. Jour. Anim. Sci. 9 : 588.

Woodward, R.R., J.R. Quesenberry, and F.S. Willson. 1954. Production and carcass quality in beef cattle. Montana State College, Circular 207, December.

Woodward, R.R., J.R. Quesenberry, R.T. Clark, et al. 1954. Relationships between preslaughter and postslaughter evaluations of beef cattle. United States Dept. Agric. Circ. No.945, May.

Yao, T.S., W.M. Dawson, and A.C. Cook. 1953. Relationship between meat production characters and body measurements in beef and milking shorthorn steers. Jour. Anim. Sci. 12 : 4.

Yao, T.S., et al. 1954. Heritability of milk production in milking Shorthorn cattle. Jour. Anim. Sci. 13 : 3.

Yao, T.S., et al. 1954. Body measurements indexes as a means of selection in Shorthorn cattle. Jour. Anim. Sci. 13: 4: 965. (Abstract).

Yapp, W.W. 1923. A dimension-weight index for cattle. Amer. Soc. Anim. Prod. Proc. 50-56.