Beef Cattle Performance

at Bluebonnet Farm

1. Evaluation Tests for Gaining Ability

Three Hereford bulls which were high gainers in the evaluation tests. Their gain ratios were 120, 127 and 140, respectively. They are now in breeding service at Bluebonnet Farm.

in cooperation with the

UNITED STATES DEPARTMENT OF AGRICULTURE

TEXAS AGRICULTURAL EXPERIMENT STATION

R. D. LEWIS, DIRECTOR, COLLEGE STATION, TEXAS
DIGEST

Efficient beef cattle must have the inherent ability to gain rapidly. Tests for this ability were made at Bluebonnet Farm by self-feeding young beef cattle together at the same place with the same feeds to determine differences among animals. Experiments were conducted to obtain more information on the part played by heredity in causing individual differences in this character and to obtain records on individual animals for use in the selection of breeding animals on Bluebonnet Farm and for cattle belonging to private breeders.

Results of these tests indicate that the rate of gain is highly heritable and that it is possible to select for a large portion of the differences in the rate. Heritability was calculated from records of 853 animals, of 2 breeds, 1 cross and 3 sex classifications. These ranged from 21 to 57 percent. The heritability value considered most reliable is that obtained by the method of regression of parent average offspring using gain ratio. Calculated from 73 parents and 291 offspring, it was 54 percent.

These high heritability figures add overwhelming support to the conclusion that selection for rate of gain will be effective when the individual's own record is used. Progeny testing is useful, but it is limited in practical application. To make progress in gaining ability, high-gaining animals must be selected.

Records made by tested bulls and heifers are listed individually in a supplement to this bulletin available on request. These records are useful to identify high-gaining individuals.

ACKNOWLEDGMENTS

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Appreciation also is expressed to the following for their assistance in these experiments: H. O. Hill, superintendent, Bluebonnet Farm; R. E. Patterson, vice director, Texas Agricultural Experiment Station; J. C. Miller, J. K. Riggs and O. D. Butler, head, associate professor and associate professor, respectively, Department of Animal Husbandry, Texas A. & M. College System; and R. D. Turk, head, Department of Veterinary Parasitology, Texas A. & M. College System.
Beef Cattle Performance at Bluebonnet Farm

1. Evaluation Tests for Gaining Ability

Bruce L. Warwick, T. C. Cartwright and M. W. Hazen *

Beef cattle production is one of the most important branches of agriculture in the Texas range areas, and is becoming increasingly important in many farming areas. Improved conservation practices result in more pasture, forage and feed grain crops. These resources can be utilized to better advantage through the production of efficient meat-producing animals. Beef is America's preferred meat, and our economy depends in large measure on more efficient conversion of grass and feed crops into edible beef. Rapid growth usually is the most economical growth. There is tremendous variability in the ability of different animals to grow on the same ration, even among animals of the same breed, age and sex. Even a small increase in the average ability to gain rapidly, if increased and stabilized by breeding, would increase potential meat production and the profit to commercial producers of beef cattle.

There have been only a few breeding experiments directed toward this goal because of the limitations of facilities at most research institutions. The acquisition of the former Bluebonnet Ordinance Plant, McGregor, Texas, now named Bluebonnet Farm, made available to the Texas Agricultural Experiment Station enough land and facilities for a full-scale breeding experiment with beef cattle aimed at the improvement of pure production characteristics.

Small herds of registered animals were acquired: Herefords by purchase and Brahman by loans and gifts from interested breeders. Also, a larger number of high grade Hereford cows was purchased for use in test matings and in crosses. Small groups of Santa Gertrudis and red Poll cattle were later added to the herd, but the small amount of data obtained from them were not included in the statistical analyses.

This bulletin is the first of a series reporting the results of investigations with beef cattle at Bluebonnet Farm. Others will include: selection in the Bluebonnet Farm herd based on performance; carcass evaluations of Hereford and first-cross Hereford x Brahman steers; weight for age at weaning; regularity of breeding; use of heat tolerance tests; and hybrid vigor.

Preliminary evaluation tests for gain were started in 1948-49 with a group of 42 unregistered Hereford calves. The first full-scale evaluation test for gain was put into operation in 1949-50 with bulls and heifers owned by Bluebonnet Farm. At that time the test also was made available to private breeders for testing bull calves. The 1950-51 test was opened to private breeders to test both heifer and bull calves.

HERITABILITY

In any group of animals of like age, breed and sex, maintained under similar conditions, some will grow or gain more rapidly than others. Part of this variation may be due to differences in heredity and part to differences in reaction to the environmental influences which cannot be identified easily. Through certain statistical procedures these two portions of the differences may be separated and measured (statistically termed variance). The part due to selectable inherited differences has been labeled “Heritability.” This can be measured effectively only when the sires or dams of tested individuals are known, or if one or both parents and the individual have been tested.

Heritability is expressed in percent and represents that portion of the variation that is sub-i.e. below 15 percent, direct selection on the individual's own record is relatively ineffective in increasing the records of the offspring. Where subject to selection. When the heritability is low,
heritability is 30 percent or higher, selection based on the individual's own record is highly effective in increasing the average of the offspring. Animals should be selected whose records are above the average of the group. This is a theoretically valid method for permanently raising the average production of the offspring over the average production of the group from which the parents are selected. However, the offspring of selected parents will not be as much above the average as their immediate parents were above the average of the group from which they were selected. This is where heritability figures apply. As an example, if both selected parents have gain ratios of 110, each would be 10 percent above the average of the group from which they were selected. If 50 percent heritability is assumed, the offspring would be expected to average 5 percent above the average of the group from which their parents were selected. Progeny from selected parents will be expected to vary about as widely as the group from which the parents were selected. Therefore, if enough progeny are produced, a few may exceed their parents in gaining ability.

**HERITABILITY OF GAINING ABILITY**

Until recently this problem received little attention but results now available are encouraging. Knapp and Nordskog (1946, 1946A) first published heritability figures for economic characters in beef cattle. Based on 177 steers and 23 bulls, heritability of rate of gain was found to be 75 percent by the paternal half-sib correlation method. By the regression of offspring-on-parent method, heritability was 97 percent. Knapp and Clark (1947), after gathering data on 422 steers and 52 bulls in the same experiment, computed heritability as 72 percent. Patterson, et al. (1949) reported on the rate of gain of animals tested at the Balmorhea substation of the Texas Agricultural Experiment Station 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. Knapp and Clark (1950) after adding more data reported revised figures that ranged from 65 percent by the half-sib correlation method to 77 percent by the regression of offspring-on-parent method. 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 83 bulls fed individually and 12 percent for 55 heifers on pasture. Cartwright (1954) working with

![Figure 1. Bulls and heifers on gain test at Bluebonnet Farm.](image)
The second method was by the regression of offspring-on-parent. Calculations were made from tested parents, either male or female, and their offspring. In most cases only one parent of the offspring had been tested. All of these cattle were raised at Bluebonnet Farm. Sixty-seven parents and the average of their offspring were included in this calculation. Heritability was calculated to be 57 percent. Also available were five additional sires tested at Balmorhea. Offspring from two of these sires were raised and tested at Bluebonnet Farm. Those from the other three sires were raised at the Texas Range Station near Barnhart and tested at Bluebonnet. When this additional information is added the figure is changed to 54 percent. Calculation of heritability by the regression of offspring-on-parent is considered the best method (Lush, 1940) since it is a more direct measure of what a parent is transmitting to its offspring and is more reliable. These calculations, again, are based on the gain ratio computed for each animal. This may not be exactly the same as the absolute gain within breed, sex, year and feed level, but the use of the gain ratio has two advantages. One is that of overcoming difficulties in analysis and the other is that selection must be made on the basis of this gain ratio or some similar method of ranking the animals. Heritability calculated from this ratio gives a better estimate of progress to be expected.

These analyses of the Bluebonnet data are presented in more technical detail by Warwick and Cartwright (1954). These heritability values, and the others reported in the literature, indicate that heritability of rate of gain in beef cattle is high. Even if the lower figures are nearer correct, marked progress can be expected by testing and selecting high-gaining bulls. Heritability values discussed here show considerable variability. They were computed from tests at four stations with different genetic material. Heritability applies directly only to the group from which data are collected. Also, some of the Balmorhea and Bluebonnet data included progeny groups from different ranches. Thus, pretest ranch differences are reflected in the analysis as genetic differences in the sires. This reduces the reliability of the calculated values. The Bluebonnet values, especially for the Herefords, are lower for the animals raised at Bluebonnet than for the entire group tested, which includes cooperator cattle from different ranches. This does not mean that heritability of rate of gain is lower for Bluebonnet cattle, but that their environmental influences are more similar.

These heritability values for gaining ability, gathered independently from various sources and computed by different methods, indicate that considerable progress can be made by a relatively simple selection program. Also, the data are extensive enough to assume that a fair sample has been tested and that almost any group of beef
cattle can be expected to fall within the range of reported values for heritability of rate of gain.

THE GAIN TEST

The gain evaluation test has been standardized as far as possible. The feed lot test begins in November and continues for 140 days after an adjustment period of 2 weeks. The earlier tests were for 154 days. Calves must have been dropped between November 1 of the previous year and April 30 of the year the test is started.

The self-fed ration for all breeding cattle consists of a mixture of cottonseed meal, ground sorghum grain, ground hegari fodder, ground Johnson grass hay, and either ground alfalfa leaf meal or vitamin A concentrate, or both. Concentrates are increased to about 30 to 35 percent during the adjustment feeding period. Steers are fed in two groups: one fed the same ration as described for the bulls and heifers, the other fed a high concentrate ration of 66 to 68 percent concentrate. Other than some of the cattle raised at Bluebonnet and the Texas Range Station, all tested animals are subject to registration. During the first 4 years covered by this analysis, the animals were in sire progeny groups of 9 or more. The requirement of a minimum number per sire group for breeding animals has been abandoned to allow more extensive testing of individuals. However, steers of any known breeding may be entered in progeny groups of 3 to 6, if otherwise qualified. These steers contribute to the evaluation of sires, breeds and crosses, and to further study of heritability.

Cattle go on test at ages differing as much as 6 months. There also is a difference in weight because of age and finish, especially in cattle of cooperators. The correlation coefficient between initial weight (beginning of test) and gain ratio (a measure of subsequent gain within year, breed, sex and ration group) based on the 920 animals tested at Bluebonnet Farm was 0.11. Between initial age and gain ratio it was 0.00. These figures indicate that there is little relationship between those variables and that neither age nor initial weight had any appreciable effect in determining subsequent gain. Stated differently, within the limits set here, age is of no value in predicting gain on the test and only about 1 percent of the variability in gain can be predicted from a knowledge of initial weight. Most cattle tested thus far entered the test in medium flesh, with only a few approaching what might be considered fat. Definite extremes probably would affect the test, but within the range from medium thin to slightly fat, the test appears valid. Similar conclusions were reached by Patterson, et al. (1949) and Patterson, et al. (1954) on the test at Balmorhea.

Selection for high gaining ability, as measured in these tests, can be effective in raising the average gaining ability of a herd. Calves raised at Bluebonnet Farm were tested to study the theoretical basis for inheritance of gain i.e. heritability, and to obtain the actual individual records for use in selection. The tests were opened to private breeders to supplement the studies of heritability, to provide comparison with calves raised on experiment at Bluebonnet Farm and to make available to the breeders entering the calves and to possible purchasers an authentic record of each animal for their use for selection purposes.

At Bluebonnet Farm, sires are being selected as much as possible from the top 25 percent in gain for the group tested the same year. In addition to the sires raised and tested at Bluebonnet Farm, two Hereford bulls were purchased in 1949 with gain test records from the 1948-49 Balmorhea test. These were the two highest gaining bulls that year. Records of the progeny of these two sires add direct support to the conclusions reached based on the theoretical considerations. These results will be presented in the second bulletin of this series. Each year all heifers belonging to Bluebonnet Farm which are in the low 25 percent of all heifers of the same breed are sold for slaughter. It is too early to evaluate the results of this culling.
RECORDS OF COMPLETED GAIN TESTS

It is important to make available in permanent form the results of the tests completed to date at Bluebonnet Farm for study and use by other breeders. To this end we have listed individually all bulls and heifers tested from 1949 through 1954. Included are the following breeds and crosses: Hereford, Brahman, Aberdeen-Angus, Santa Gertrudis, Charbray, Shorthorn, Red Poll and Charolaise. The only unregistered animals or animals not approved for registry included are unregistered Hereford heifers raised at Bluebonnet Farm and the Texas Range Station, and one Brahman heifer the first year. The records have been listed within breed and sex groups by rank of the gain ratio, i.e., 100 (total individual gain/average gain for group). These tables show which animals had superior gaining ability. Sires whose progeny were tested are listed separately in alphabetical order by owner. Each sire is numbered, and this number is the sire code appearing in the individual-record tables. By cross reference, a sire's rank, owner's complete name and address, and other information can be determined. For each breed and cross, information is presented in the following order: individual records of bulls, averages by year for daily gain of bulls, individual records of heifers and averages by year for daily gain of heifers. The sire list follows the individual records of all breeds and gives the full name and address of the owner. The records are for the five tests from 1949-50 through 1953-54.

These lists have been prepared as a supplement to this bulletin and are available upon request. A partial list of one breed is given in Table 1 for illustration. This is arranged like the supplement listing, the animals with the highest gain ratios first. Only the highest seven, one average and the two lowest of this breed and sex are included. One of the bulls with a daily gain of 2.3 pounds was the highest gaining Hereford in the year tested and had a gain ratio of 125. Another bull tested a different year gained 2.4 pounds per day but the gain ratio was only 100. This shows that the actual pounds of gain must be considered in relation to the performance of the other animals of the same group tested the same year, i.e., the gain ratio. It is recommended that the gain ratio be used directly for selection, using only sires with gain ratios above 100, preferably those with the highest ratios. The wide range of variation between animals of the same breed, sex and year group emphasizes the possibility of greatly increasing average growth or daily gain by selection.

DISCUSSION

It has been established that gaining ability, probably the most important character in beef cattle, can be improved by selecting high gaining individuals as herd sires and cow replacements. Records such as those given in the supplemental table are necessary to establish which are superior individuals. Since a lot of weight is given to the records in selection, some careful study of the records is required. Gains are different from year to year and among sexes and breeds. These should be taken into consideration, especially if animals are tested under different conditions.

It is necessary to evaluate an animal relative to its sex group which was tested under the same conditions. An animal's daily gain in pounds is interesting and has some value but of more importance is the relative value of the record of the animal. It has been found very useful at Bluebonnet Farm to use the gain ratio for this pur-

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**TABLE 1. EXAMPLES OF PERFORMANCE OF HEREFORD BULLS TESTED, 1949-50 — 1953-54**

<table>
<thead>
<tr>
<th>Name of animal</th>
<th>Registry number</th>
<th>Sire code</th>
<th>Owner</th>
<th>Daily gain, lbs.</th>
<th>Gain ratio</th>
<th>Rank in year tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. B. F. 909</td>
<td>7303034</td>
<td>6</td>
<td>Bluebonnet</td>
<td>3.1</td>
<td>140</td>
<td>53</td>
</tr>
<tr>
<td>Mr. B. F. 828</td>
<td>7303031</td>
<td>7</td>
<td>Bluebonnet</td>
<td>2.9</td>
<td>132</td>
<td>53</td>
</tr>
<tr>
<td>Windermere 27th</td>
<td>6155170</td>
<td>25</td>
<td>Storts</td>
<td>3.0</td>
<td>130</td>
<td>51</td>
</tr>
<tr>
<td>Mr. B. F. 3129</td>
<td>7877819</td>
<td>69</td>
<td>Bluebonnet</td>
<td>3.1</td>
<td>129</td>
<td>54</td>
</tr>
<tr>
<td>H. L. Domino Chief 23d</td>
<td>6529152</td>
<td>23</td>
<td>Bluebonnet</td>
<td>2.9</td>
<td>128</td>
<td>52</td>
</tr>
<tr>
<td>Bluebonnet Farm 685</td>
<td>6792515</td>
<td>3</td>
<td>Bluebonnet</td>
<td>2.8</td>
<td>127</td>
<td>52</td>
</tr>
<tr>
<td>Bobby</td>
<td>5756748</td>
<td>3</td>
<td>Bluebonnet</td>
<td>2.3</td>
<td>125</td>
<td>50</td>
</tr>
<tr>
<td>Mr. B. F. 1047</td>
<td>7877811</td>
<td>89</td>
<td>Bluebonnet</td>
<td>2.4</td>
<td>100</td>
<td>54</td>
</tr>
<tr>
<td>SF 500</td>
<td>6346452</td>
<td>6</td>
<td>Bluebonnet</td>
<td>1.2</td>
<td>51</td>
<td>51</td>
</tr>
<tr>
<td>Mr. B. F. 3274</td>
<td>7877822</td>
<td>89</td>
<td>Bluebonnet</td>
<td>1.0</td>
<td>43</td>
<td>54</td>
</tr>
</tbody>
</table>

**Table 1**

<table>
<thead>
<tr>
<th>Year</th>
<th>Number tested</th>
<th>Average</th>
<th>Lowest</th>
<th>Highest</th>
<th>Gain ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>11</td>
<td>1.8</td>
<td>1.2</td>
<td>2.3</td>
<td>64</td>
</tr>
<tr>
<td>1951</td>
<td>31</td>
<td>2.3</td>
<td>1.2</td>
<td>3.0</td>
<td>51</td>
</tr>
<tr>
<td>1952</td>
<td>38</td>
<td>2.2</td>
<td>1.7</td>
<td>2.9</td>
<td>76</td>
</tr>
<tr>
<td>1953</td>
<td>32</td>
<td>2.2</td>
<td>1.5</td>
<td>3.1</td>
<td>69</td>
</tr>
<tr>
<td>1954</td>
<td>12</td>
<td>2.4</td>
<td>1.0</td>
<td>3.1</td>
<td>43</td>
</tr>
</tbody>
</table>

The complete list of bulls and heifers tested is available as a supplement to this bulletin. Names, registry numbers and owner included in the supplement. Owner's names and addresses included in the supplement.
pose. The gain ratio simply denotes the animal's standing in relation to the average of its group.

To the breeder who is interested in improving beef cattle for economic purposes that are useful to the commercial producer, it is recommended that he give rate of gain first consideration, being careful in obtaining and evaluating records.

GLOSSARY

Correlation: A measure of the closeness of association of two things. Perfect correlation is represented by 1.0, and no correlation by 0.

$F_1$: First generation produced by crossing two breeds.

Gain Ratio: As used in this bulletin, it is 100 times the total gain on test of an individual divided by the average total gain on test of all animals of the same year, breed, sex and ration group. See text for an example.

Heritability: Statistically, the fraction of the variation between animals due to selectable hereditary differences. See text for a more complete discussion.

Regression: Average change in one of two characters per unit change in the other. For example, the regression of weight on age measures the average number of pounds (or other measure of weight) of weight increase for an increase in age of one unit (days, months, etc.).

Sib: A brother or sister. Half-sibs are half-brothers or half-sisters.

LITERATURE CITED


The individual records of all bulls and heifers tested at Bluebonnet Farm 1949 through 1954 are available as supplementary tables to this Bulletin 790. Write to

Agricultural Information Office
Texas A. & M. College System
College Station, Texas