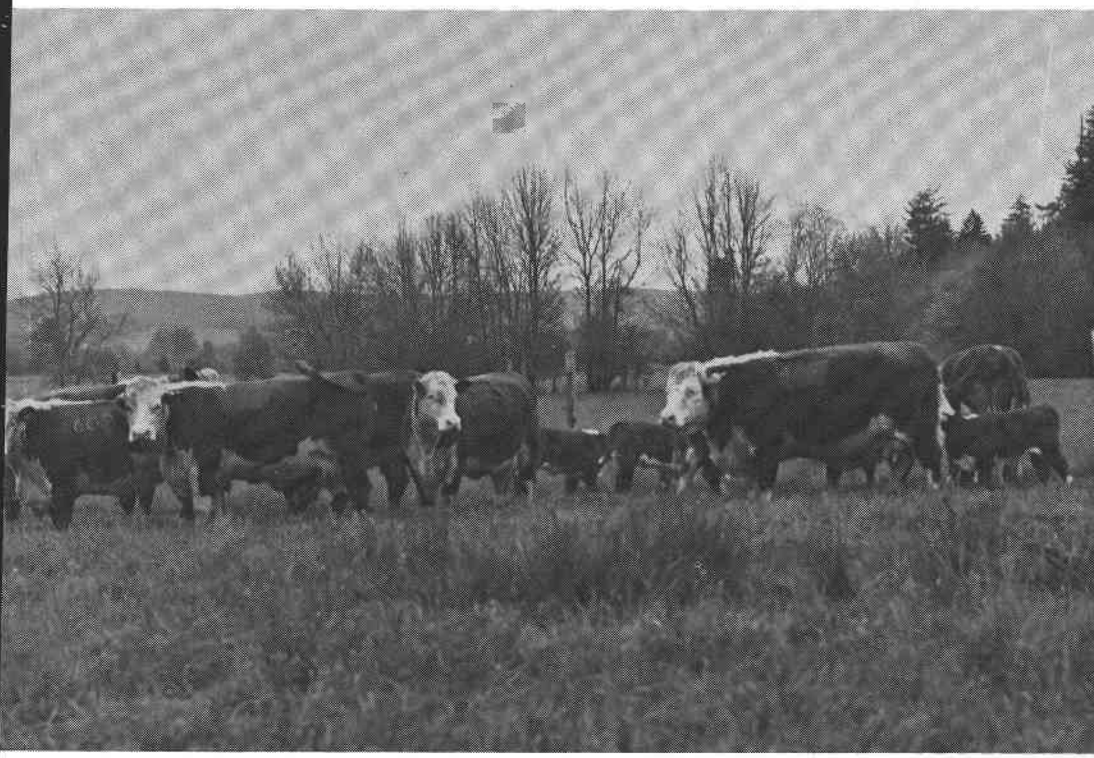
*Summary of reports . . .*

# Eleventh Annual

# Beef Cattle Day



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## Contents



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# Evaluating Cutability in Relatively Uniform Lots of Finished Steers

W. H. KENNICK, R. S. TURNER, and K. E. ROWE

Several workers have studied methods of predicting beef carcass cutability and have determined various prediction equations for estimating the yield of trimmed retail cuts from these carcasses.

In most instances the carcasses used for such studies were quite variable in weight and finish, as indicated by the standard deviation of the various carcass measures used. It has been suggested that the influence of various carcass characteristics upon cutability may be different with more uniform groups of cattle.

The Oregon State Meat Science Laboratory therefore undertook to determine the validity of two of the more accepted methods of predicting cutability when they are applied to a relatively uniform group of steers. The USDA yield grading system and the Wisconsin equation, which uses the wholesale round as one of the predictor measures, were used in this experiment.

In order to carry out this investigation, it was necessary to determine the actual yield of trimmed retail cuts from the beef carcasses involved; in so doing, data were gathered which made it possible to construct prediction equations which would apply to the type of beef carcasses studied.

Forty-four steers from the Department of Animal Science's Adair herd were fed in the OSU nutrition barn, under the direction of Dr. D. C. Church, to an approximate slaughter weight of 1,050 pounds. They were slaughtered at the OSU Meat Science Laboratory and, after proper aging, the left side of each carcass was cut into trimmed retail cuts (Figure 1).

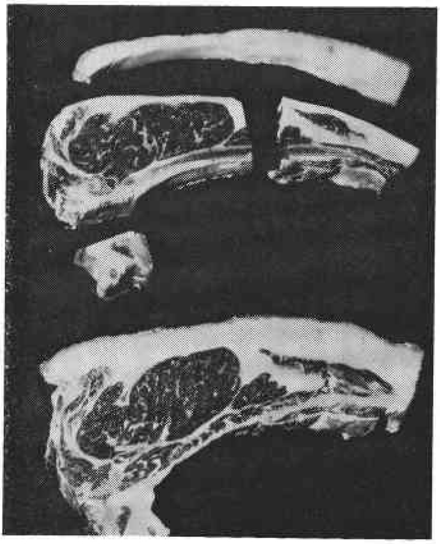

**Figure 1. Method of trimming to prepare trimmed retail cut from rib.**

The characteristics evaluated in this study, with their means and standard deviations, are presented in Table 1.

From these data it was possible to determine the predicted yield by the USDA and Wisconsin methods and to compare these methods and their efficiency in predicting the yield of trimmed retail cuts as actually measured.

The results of these comparisons indicated that the two methods were of

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## Table 1. Means and Standard Deviations of Measured and Predicted Values

| Variable | Mean | Standard deviation | Number of observations |
|---|---|---|---|
| Live weight, lbs. | 1049.77 | 25.22 | 52 |
| Cold carcass weight, lbs. | 629.56 | 18.87 | 52 |
| Conformation score* | 17.15 | .83 | 52 |
| USDA grade* | 16.21 | .85 | 52 |
| Percent of kidney fat | 2.04 | .57 | 52 |
| Rib eye area (sq. in.) | 10.92 | .73 | 50 |
| Rib, total lean areas (sq. in.) | 13.10 | .88 | 43 |
| Rib, total area (sq. in.) | 20.29 | 1.73 | 43 |
| Rib, miscellaneous lean (sq. in.) | 2.16 | .37 | 43 |
| Percent of lean area in exposed rib | 64.84 | 5.10 | 43 |
| Back fat thickness, in. | .60 | .21 | 48 |
| Left side weight, lbs. | 308.57 | 9.54 | 44 |
| Fore quarter weight, lbs. | 158.25 | 6.25 | 44 |
| Square chuck weight, lbs. | 81.78 | 3.64 | 44 |
| Retail cuts, square chuck, lbs. | 62.58 | 3.93 | 44 |
| Rib weight, lbs. | 29.46 | 1.83 | 44 |
| Retail cuts, rib, lbs. | 18.85 | 1.18 | 44 |
| Plate weight, lbs. | 24.18 | 2.13 | 44 |
| Shank weight, lbs. | 10.16 | .60 | 44 |
| Brisket weight, lbs. | 12.50 | 1.31 | 44 |
| Hind quarter weight, lbs. | 150.32 | 4.93 | 44 |
| Round weight, lbs. | 68.91 | 3.28 | 44 |
| Retail cuts, round, lbs. | 41.95 | 2.80 | 44 |
| Trimmed loin weight, lbs. | 51.40 | 2.85 | 44 |
| Retail cuts, loin, lbs. | 34.57 | 1.57 | 44 |
| Flank weight, lbs. | 19.96 | 2.29 | 44 |
| Lean trimmings, lbs. | 64.29 | 5.05 | 44 |
| Fat trimmings, lbs. | 61.47 | 11.09 | 44 |
| Bone weight, lbs. | 22.84 | 2.13 | 44 |
| Yield of trimmed retail cuts, lbs. | 157.95 | 7.05 | 44 |
| Percent of trimmed retail cuts | 51.20 | 2.15 | 44 |
| Yield of salable cuts, lbs. | 222.24 | 9.60 | 44 |
| Percent salable cuts | 72.05 | 3.04 | 44 |
| USDA prediction of percent trimmed retail cuts | 49.09 | 1.62 | 48 |
| Wisconsin prediction of lbs. of trimmed retail cuts | 155.92 | 6.21 | 43 |

* Average good = 14, average choice = 17.

almost exactly the same efficiency in predicting cutability and that neither of them was sufficiently precise to account for 50% of the variation in yield of trimmed retail cuts.

As a result of this lack of precision, an attempt was made to fit a more precise prediction equation to these data. This work was carried out at the OSU Computer Center. Without the computer, such calculations would be virtually impossible.

The first step in this study was to run simple correlation coefficients between all possible pairs of the thirty-five observations recorded for each carcass. This made it possible to make a preliminary evaluation of the possible contribution each observation made to carcass composition as well as of their relationships to one another. The simple correlations of observations and predicted yields to actual pounds and percent yield of trimmed retail cuts from the round, loin, rib, and chuck are included in Table 2.

Eighteen variables which might make a significant contribution to an equation that would predict cutability were chosen from this table.

A stepwise multiple linear regression analysis was used to develop equations to predict pounds and percent trimmed retail cuts for these data. In this type of analysis the variable with the highest simple linear correlation is chosen first as a predictor variable. Additional variables are chosen in order of

**Table 2. Correlations of Measured and Predicted Values with Pounds and Percent of Trimmed Retail Cuts**

| Variable | Trimmed Retail Cuts | |
|---|---|---|
| | Weight or pounds | Percent |
| Live weight, lbs. | 0.319 | -0.074 |
| Cold carcass weight, lbs. | 0.410 | -0.270 |
| Conformation score | -0.248 | -0.502 |
| USDA grade | -0.343 | -0.449 |
| Percent of kidney fat | -0.280 | -0.471 |
| Rib eye area (sq. in.) | 0.463 | 0.339 |
| Rib, total lean areas (sq. in.) | 0.348 | 0.255 |
| Rib, total area (sq. in.) | 0.105 | -0.304 |
| Rib, miscellaneous lean (sq. in.) | -0.100 | -0.113 |
| Percent of lean area in exposed rib | 0.167 | 0.538 |
| Back fat thickness, in. | -0.313 | -0.620 |
| Left side weight, lbs. | 0.431 | -0.279 |
| Fore quarter weight, lbs. | 0.495 | -0.127 |
| Square chuck weight, lbs. | 0.596 | 0.157 |
| Retail cuts, square chuck, lbs. | 0.897 | 0.627 |
| Rib weight, lbs. | 0.083 | -0.387 |
| Retail cuts, rib, lbs. | 0.450 | 0.220 |
| Plate weight, lbs. | 0.120 | -0.260 |
| Shank weight, lbs. | 0.543 | 0.457 |
| Brisket weight, lbs. | 0.043 | -0.227 |
| Hind quarter weight, lbs. | 0.207 | -0.379 |
| Round weight, lbs. | 0.660 | 0.455 |
| Retail cuts, round, lbs. | 0.749 | 0.632 |
| Trimmed loin weight, lbs. | 0.002 | -0.338 |
| Retail cuts, loin, lbs. | 0.571 | 0.488 |
| Flank weight, lbs. | -0.246 | -0.635 |
| Lean trimmings, lbs. | 0.237 | 0.154 |
| Fat trimmings, lbs. | -0.385 | -0.775 |
| Bone weight, lbs. | 0.158 | 0.136 |
| Yield of trimmed retail cuts, lbs. | 1.000 | 0.746 |
| Percent of trimmed retail cuts | 0.746 | 1.000 |
| Yield of salable cuts, lbs. | 0.860 | 0.629 |
| Percent salable cuts | 0.564 | 0.848 |
| USDA prediction of percent trimmed retail cuts | 0.384 | 0.672 |
| Wisconsin prediction of lbs. of trimmed retail cuts | 0.680 | 0.380 |

$p_{.05} = .286$; $p_{.01} = .372$

their contribution to predictability. Additional variables can be included until all have been included or none of the remaining variables contribute to the prediction equation. A subjective decision is necessary to determine the minimum number of variables to be included in a final prediction equation.

The selected prediction equations for percent and pounds of trimmed retail cuts from the round, loin, rib, and chuck were as follows:

Percent trimmed retail cuts = 5.44 − (0.61 × conformation score) + (0.67 × rib eye area) − (3.71 × fat thickness over the eye) + (0.13 × weight of chuck) − (0.44 × weight of flank).

Coefficient of determination = .757
Standard error = 1.13

Pounds of trimmed retail cuts = 4.24 + (1.75 × cold carcass weight) − (1.49 × conformation score) + (1.83 × rib eye area) − (8.15 × fat thickness over the rib eye) + (0.52 × square chuck weight) + (0.50 × round weight) − (1.15 × flank weight).

Coefficient of determination = .815
Standard error = 3.32

The coefficient of determination is a measure of the percentage of the variation in the predicted characteristic which is accounted for by the equation. Therefore, the two preceding equations account for 75.7% of the variation in percent of trimmed retail cuts and 81.5% of the variation in pounds of trimmed retail cuts in these data.

This is a substantial improvement over the percent of variation accounted for by the USDA (44.2%) and the Wisconsin (46.4%) prediction equations as applied to these data. The USDA and Wisconsin equations were derived from data collected from carcasses which were much more variable in weight and finish than those used in this experiment. As applied to the data from which they were collected, the two equations accounted for 77 and 82%, respectively, of the variation in trimmed retail cuts. The Wisconsin workers, using the same measurements as used in the USDA equation, found that they accounted for 67 percent of the variation in percent retail yield when applied to choice carcasses varying in weight from approximately 520 to 720 pounds.

Since the cost of application of any method of estimating carcass composition will have a bearing upon how much it is used, we felt that a procedure requiring less cutting of the carcass would be desirable. We therefore reanalyzed the data using a forcing procedure that resulted in equations which included only easily obtainable carcass data and weight of primal cuts from the hind quarter. The resulting equations were as follows:

Percent trimmed retail cuts = 56.36 − (0.64 × conformation score) + (0.57 × rib eye area) − (2.48 × fat thickness over the rib eye) + (0.14 × weight of the round) − (0.44 × weight of the flank).

Coefficient of determination = .745
Standard error = 1.15

Pounds of trimmed retail cuts = 10.42 + (0.26 × cold carcass weight) − (2.27 × conformation score) + (2.19 × rib eye area) − (8.85 × thickness of fat over the eye) + (0.41 × weight of the round) − (1.27 × weight of the flank).

Coefficient of determination = .783
Standard error = 3.54

It can be seen from a comparison of the coefficients of determination (.757 and .815 versus .745 and .783) and standard errors (1.13 and 3.32 versus

1.15 and 3.54) that using only easily obtainable carcass data and weights of cuts from the hind quarter does not appreciably reduce the accuracy or precision of the prediction equation.

The authors therefore feel that one of the latter two equations should be used when evaluating the yield of relatively uniform carcasses using gross carcass data and weight of primal cuts.

# Protein and Energy Requirements of Steers Fed Complete Rations

D. C. Church

For several years we have been carrying out experiments designed to investigate the protein and energy needs of calves fed complete rations. Protein, of course, usually is the most expensive ration ingredient. Obviously, the less protein required for optimum performance, the less expensive should be the gain. The ration with an optimum amount of protein may or may not be the cheapest formula, however. Likewise, energy may be relatively expensive and it is desirable to utilize it efficiently.

With one exception, the experiments that will be discussed also have involved rations formulated with the aid of a computer. Computer-formulated rations (least cost or linear programmed rations) have been utilized to study the use of such rations and the feasibility of using such formulation practices. The computer-formulated rations in these experiments have the disadvantage of bringing in a variety of feedstuffs that may, at times, complicate the interpretation of results. This comment applies, particularly, if the physical texture of a ration is modified substantially with resultant changes in palatability. It is also probable, at times, that certain feedstuffs or mixtures of feedstuffs may be more or less palatable than others regardless of the physical texture of the ration.

Complete rations have been utilized because of the simplicity of feeding and keeping accurate records of feed consumption. It might be more practical to feed chopped hay or silage along with a concentrate feed, but this results in less accurate estimates of feed consumption and/or greatly increases the feeding costs for labor when records are desirable on individual animals. Except for Trial 5, all animals were individually fed (Figure 1).

**Figure 1. Some of the steers and the individual feeding facilities used in OSU nutrition studies.**

Dr. Church is associate professor of animal nutrition, Oregon State University.

Steer calves from our Adair herd were used in these experiments. They were brought to the experimental feeding barn two to three weeks after weaning and placed on a starter ration. Generally, the calves were started on the experimental rations after a period of four to six weeks, or they were started at a specific weight, usually about 615 to 630 pounds. The finished animals were removed on the basis of body weight or condition, usually at weights of 1,025 to 1,050 pounds. Cattle were implanted regularly with diethylstilbestrol at the beginning of the trial and again when they had put on about one half of their expected gain. Average daily gain for the total experimental period and feed conversion data are calculated on the basis of an unshrunk initial body weight and on the basis of final weights derived from carcass weights, the latter value being used to avoid differences in fill.

An example of some of the rations that were used in 1966-1967 (Trial 4) is shown in Table 1. The experimental rations were formulated to be the same with respect to fiber percentage and to have equivalent amounts of calcium and phosphorus; usually there were restrictions on the maximum amounts of alfalfa, molasses, urea, and tallow that could be added. As a result, the computer put in dabs of this and trickles of that in order to exactly meet the ration specifications for digestible protein and energy and still have a minimum cost. Such rations might require some modification to be practical on a commercial basis.

The rations usually were formulated on the basis of digestible protein, using typical book values. Obviously, there may be a considerable error in this procedure. Likewise, energy values utilized may or may not be appropriate. The rations usually were formulated using values for net energy or net energy of production. For those more familiar with the total digestible nutrient (TDN) system, the "low," "medium,"

**Table 1. An Example of Some Rations Used in Trial 4 (pounds per ton)**

| Feed ingredient | Control ration | 8.5% DP* low energy | 8.5% DP* high energy | 10% DP high energy |
|---|---|---|---|---|
| Alfalfa pellets, lbs./T | 200 | 100 | 100 | 100 |
| Ryegrass screenings, lbs./T |  | 300 | 300 | 300 |
| Cottonseed meal, lbs./T |  |  |  | 98 |
| Safflower meal, lbs./T |  |  | 156 | 131 |
| Urea, lbs./T |  | 20 | 15 | 20 |
| Molasses, lbs./T | 100 | 200 | 200 | 200 |
| Barley, steam rolled, lbs./T | 1,100 | 46 |  |  |
| Oats, steam rolled, lbs./T |  | 901 |  |  |
| Wheat, steam rolled, lbs./T |  |  | 1,152 | 1,068 |
| Beet pulp, lbs./T | 100 |  |  |  |
| Wheat mill run, lbs./T | 479 | 395 |  |  |
| Tallow, lbs./T |  |  | 38 | 44 |
| Salt, trace min., lbs./T | 20 | 20 | 20 | 20 |
| Limestone, lbs./T |  | 16 | 1 | 5 |
| Tricalcium phosphate, lbs./T |  | 1 | 17 | 13 |
| Antibiotic premix, lbs./T | 1 | 1 | 1 | 1 |
| Vitamin A premix | + | + | + | + |
| Commercial price, $/T | 70.70 | 61.82 | 70.09 | 73.22 |

* DP = digestible protein.

and "high" energy values are on the order of 64, 67, and 70% TDN. The control ration is about 71% TDN. The high level (70 to 71% TDN) may not be considered a high energy ration in some situations.

**Trials with protein levels**

Animal performance for the total experimental period in each of the various trials is shown in Table 2. Rations containing a low energy level were used in the first experiment (Trial 1). Results indicated that a level of digestible protein (DP) of 7.1% was preferable in terms of daily gain and feed conversion to rations with higher levels of protein (7.7 or 8.6% DP). In this particular experiment, digestible protein was actually determined with lambs, so the levels listed are a valid estimate of the amount in the rations.

Subsequent experiments (Trials 2, 3, 4, and 5), however, generally indicate that animal response was more favorable with the higher levels of estimated DP when the level of protein was constant throughout the trial and when combined with higher energy levels. For example, note the results in Trial 3. The first three rations fed (Table 2, lines 7, 8, and 9) had 7, 8.5, or 10% DP with a medium energy level. The gain and feed conversion were improved by feeding 10% DP as compared to 7 or 8.5%. Likewise, the cost of gain was less. The same results will be observed in Trials 4 (lines 13, 15) and 5 (lines 16, 17) for the rations which had constant levels of protein.

In practice, many feeders tend to feed a given amount of a protein supplement and gradually increase the grain while reducing the roughage fed to finishing steers. This results in a gradually decreasing protein percentage if computed on the basis of the total ration consumed. In order to simulate this condition, variable levels of DP were fed in Trials 3 and 4. In these experiments, rations were shifted when an individual steer had made one third and two thirds of expected total gain.

Note the results in Trial 3. One lot was fed a ration with 8.5% DP with low, medium, and high energy levels (Table 2, line 10) and can be compared to a lot fed 10, 8.5, and 7% DP with low, medium, and high energy (line 11) or to the third lot fed 10, 8.5, and 7% DP with medium energy throughout (line 12). The results here indicate that the 8.5% DP throughout along with increasing energy gave somewhat better animal response at a reduced cost than did the 10-8.5-7 treatment with increasing energy levels. However, the 10-8.5-7 level of DP with a medium energy level resulted in somewhat more gain and a reduced cost of gain than did the other two treatments (lines 10, 11).

In the case of Trial 4, results were quite similar, although feed conversion tended to be somewhat higher for the lot fed 8.5% DP (line 13). When steers were fed what the author terms high energy rations (control ration, Table 1; Trial 5, Table 2), data indicate that a ration with about 10.6% DP (line 17) resulted in a better performance than a ration with a lower level of protein (8.6% DP).

Data from Trials 3 and 4 by periods ($\frac{1}{3}$ of the gain in each period) are shown in Table 3. Results from these two trials tend to indicate that 7% DP is too low for the early part of the finishing period with medium energy rations, but either 8.5 or 10% DP would seem to be adequate for low or medium rations. Results are variable during the middle third of the finishing period, but they generally indicate that

**Table 2. Response of Steers to Various Complete Rations Differing in Digestible Protein and in Energy Level**

| Trial no. | | No. of steers | Digestible protein | Energy level | Average feed consumption | Feed conversion | Avg. daily gain | Marbling score | Back fat | Ribeye area | Feed cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *%* | | *lbs./day* | | *lbs.* | | *in.* | *in²/cwt.* | *$/cwt.* |
| 1 | (1)* | 12 | 7.14 | Low | 19.0 | 7.06 | 2.71*** | 12.1 | .39 | 1.96 | 20.05 |
| | (2) | 14 | 7.71 | Low | 18.0 | 7.03 | 2.57 | 12.6 | .42 | 1.94 | 20.26 |
| | (3) | 12 | 8.65 | Low | 17.8 | 7.45 | 2.40 | 12.8 | .35 | 1.98 | 21.10 |
| 2** | (4) | 6 | 7.0 | Variable | | 6.49 | 2.60 | 11.8 | .46 | | 19.81 |
| | (5) | 6 | 8.5 | Variable | | 6.46 | 2.52 | 9.6 | .37 | | 20.50 |
| | (6) | 4 | 10.0 | Variable | | 5.96 | 2.70 | 8.5 | .36 | | 19.91 |
| 3 | (7) | 5 | 7.0 | Medium | 18.9 | 7.01 | 2.72 | 12.2 | .55 | 1.98 | 20.99 |
| | (8) | 4 | 8.5 | Medium | 19.0 | 7.10 | 2.68 | 12.2 | .44 | 1.98 | 21.30 |
| | (9) | 5 | 10.0 | Medium | 19.0 | 6.69 | 2.85 | 12.2 | .57 | 1.92 | 19.95 |
| | (10) | 10 | 8.5 | L-M-H | 18.1 | 6.29 | 2.89 | 11.4 | .54 | 1.97 | 19.10 |
| | (11) | 9 | 10–8.5–7 | L-M-H | 18.9 | 6.82 | 2.78 | 11.4 | .56 | 1.87 | 20.79 |
| | (12) | 9 | 10–8.5–7 | Medium | 19.2 | 6.28 | 3.05 | 9.4 | .58 | 1.90 | 18.76 |
| 4 | (13) | 9 | 8.5 | L-M-H | 19.2 | 7.71 | 2.50 | 11.6 | .40 | 1.94 | 25.29 |
| | (14) | 10 | 10–8.5–7 | L-M-H | 20.0 | 7.53 | 2.66 | 14.0 | .45 | 1.88 | 26.06 |
| | (15) | 9 | 10.0 | L-M-H | 19.9 | 7.55 | 2.64 | 13.0 | .42 | 1.91 | 25.54 |
| 5 | (16) | 5 | 8.6 | High | 19.8 | 6.60 | 2.98 | 12.0 | .48 | 1.72 | 21.20 |
| | (17) | 5 | 10.6 | High | 19.8 | 6.42 | 3.09 | 13.2 | .62 | 1.84 | 20.68 |
| | (18) | 5 | 8.5 | High + 3% fat | 20.6 | 6.29 | 3.28 | 13.4 | 1.01 | 1.69 | 20.62 |

* Numbers in parentheses refer to line number of table.
** Pelleted rations.
*** Statistically greater gain.

**Table 3. Feed Consumption and Gain by Periods When Steers Were Fed Rations Varying in Protein or Energy**

| Trial no. | Ration | Period 1 | | | Period 2 | | | Period 3 | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Live wt. | Feed eaten | Gain | Live wt. | Feed eaten | Gain | Live wt. | Feed eaten | Gain | Live wt. | Feed eaten | Gain |
| | | *Lbs.* | *Lbs.* | *Lbs.* | *Lbs.* | *Lbs.* | *Lbs.* | *Lbs.* | *Lbs.* | *Lbs.* | *Lbs.* | *Lbs.* | *Lbs.* |
| 3 | 7% DP, ME | 705 | 17.0 | 2.78 | 844 | 17.2 | 2.81 | 971 | 22.5 | 2.49 | 838 | 18.8 | 2.72 |
| | 8.5% DP, ME | 704 | 18.6 | 3.16 | 844 | 18.4 | 2.66 | 976 | 19.8 | 2.28 | 840 | 19.0 | 2.68 |
| | 10% DP, ME | 703 | 17.6 | 3.09 | 842 | 19.9 | 3.13 | 983 | 20.4 | 2.40 | 843 | 19.0 | 2.85 |
| | 8.5% DP, L-M-HE | 702 | 16.6 | 3.20 | 843 | 17.8 | 2.94 | 977 | 19.8 | 2.58 | 840 | 18.1 | 2.89 |
| | 10–8.5–7% DP L-M-HE | 703 | 16.5 | 3.00 | 843 | 19.5 | 3.02 | 976 | 20.3 | 2.36 | 840 | 18.9 | 2.78 |
| | 10–8.5–7% DP, ME | 704 | 15.8 | 3.21 | 845 | 20.2 | 3.35 | 987 | 21.2 | 2.74 | 846 | 19.2 | 3.05 |
| 4 | 8.5% DP L-M-HE | 692 | 16.7 | 3.03 | 841 | 21.9 | 3.01 | 956 | 18.0 | 1.61 | 824 | 19.2 | 2.50 |
| | 10% DP L-M-HE | 692 | 19.0 | 3.06 | 838 | 21.8 | 2.93 | 964 | 19.2 | 2.10 | 828 | 19.9 | 2.64 |
| | 10–8.5–7% DP L-M-HE | 694 | 18.7 | 3.23 | 836 | 20.1 | 3.12 | 962 | 20.6 | 1.90 | 828 | 20.0 | 2.66 |

8.5% DP is probably adequate. In the final third, 7% DP would appear to be adequate for medium energy rations, but as much as 10% may be necessary for high energy rations.

### Energy levels

With respect to energy levels, the comparisons available are not as extensive as for protein. Previous research indicates that a level of digestible energy about the same as the control ration (TDN about 71%) would appear to result in maximum gains under our experimental conditions when tallow was not fed. The results reported here indicate that a medium level of energy will result in a level of performance just as great as a low-medium-high combination. In Trial 5, the addition of animal tallow to the control ration produced additional gain. Some of the benefits of tallow, however, may be a result of less dust, improved palatability, and perhaps less gas (methane) formation in the rumen in addition to the actual energy added.

### Suggested levels of protein

As previously mentioned, there were complicating factors in these experiments, particularly in the use of computer-formulated rations. These experiments were intended to serve as pilot trials. Because a small number of animals was used, the results are less confident. It is possible that field testing of similar rations may result in different relative performances.

The approximate levels of digestible protein that would seem to be preferable are suggested in Table 4.

**Table 4. Suggested levels of digestible protein for steer calves when fed rations with different energy levels**

| | Digestible protein | | |
|---|---|---|---|
| | Stage of finishing | | |
| Energy level | Early | Middle | Late |
| | % | % | % |
| Low | 8.5 | 7.5–8 | 7 |
| Medium | 8.5–10 | 8.5 | 7–8 |
| High | 10–11 | 10 | 8.5–10 |

An explanation of the different protein requirements for different energy levels is probably warranted. The reason is that energy consumption is fairly well regulated by the animal. In other words, a calf will eat about the same amount of energy from a low energy ration as from a high energy ration *if* physical capacity is not limiting. Therefore, he takes in a greater poundage and, consequently, more protein on the low energy ration. The result is that a smaller percentage of protein will result in the same total protein consumed on a high energy ration. This is a simplified explanation and may be modified by the amount of fiber in the ration or by factors such as pelleting which modify palatability and feed intake.

# Beef Cattle Breeding Studies

RALPH BOGART

The original objectives of the beef breeding project were: (1) To determine if small closed populations (one- and two-sire herds) could be maintained without declines in performance; (2) to determine what progress could be made from selection for production performance in small closed populations; (3) to determine what value inbred populations might have for beef improvement; and (4) to determine some of the physiological differences between rapidly gaining and slowly gaining animals by analyzing the blood for precursors used in muscle development and analyzing the blood and liver for certain enzyme activities which might be associated with muscle or fat deposition.

## Establishment and evaluation of lines

In 1948, three lines of Herefords and one line of Angus were started. They were bred essentially as closed populations with male and female replacements selected within each line. One line of Herefords (line 1) was based on males and females obtained from Earlscourt Ranch in British Columbia, Canada. The other two lines were based on use of a heterogenic group of cows at Oregon State, with a bull from the Crow Ranch heading up line 2 and a bull from the Fulcher Ranch heading up line 3. Lines 2 and 3 had some common genetic background because of the cows used to establish these lines. The Angus line was started from a combination of the Angus cows of heterogenic breeding, using Prince Sunbeam and Missouri Barbara bulls. Later, a Blackdee bull was introduced into the herd.

The three Hereford lines were maintained essentially as one-sire and 15-cow lines, while the Angus line was a two-sire and 20-cow line. Selection was based on equal emphasis on suckling gains, feed-test gains, feed efficiency, and score for conformation. All animals were put through a feed test from 500 to 800 pounds body weight on a ration composed of two parts roughage to one part concentrate.

In the three Hereford (one-sire) lines, there was first an improvement, then a plateau, then a decline in rate and efficiency of gains and conformation. Suckling gains in these three lines showed no change initially and then declined. Improvement in all traits has occurred to the present time in the Angus line.

**Figure 1. A closed herd of Angus cows and calves. The average suckling gains of all calves born in 1968 were 2.34 and 1.88 pounds per day for males and females respectively. The 205-day adjusted weights were 550 and 455 for males and females.**

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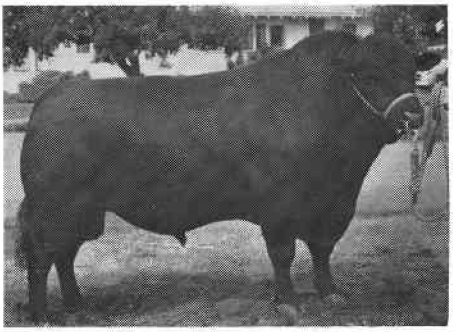

**Figure 2. OSU Sir Blackdee 561. He had a suckling gain of 2.51 and test gain of 3.21 pounds per day, required 5.32 pounds feed per pound gain, scored 13.2 out of a possible 15 for conformation, and reached 1,000 pounds at 298 days of age.**

## Line crossing

It appeared essential that we combine lines for re-establishment of lines with greater genetic diversity in our Herefords. A diallel mating plan was designed so measurements could be made of general and specific combining ability and hybrid vigor. This mating plan is shown in outline:

| Line of sire | Line of dam | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| 1 | 1 x 1 | 1 x 2 | 1 x 3 |
| 2 | 2 x 1 | 2 x 2 | 2 x 3 |
| 3 | 3 x 1 | 3 x 2 | 3 x 3 |

General combining ability is the ability of a particular line to combine with all other lines either in a better or worse direction. Specific combining ability is the ability of any two lines to combine. Hybrid vigor is measured by comparing inbred performance with performance of linecrosses.

Evaluations were made from records on suckling gains, feed-test gains, conformation and condition scores, and feed efficiency of all calves. The bulls were fed to a weight of 1,000 pounds and slaughtered so data could be obtained on dressing percent, marbling, loin-eye area, grade, percent lean, fat, and bone, and organoleptic appraisals of the cooked meat. In addition, blood levels of urea and amino acid nitrogen and the liver enzyme activity of the coenzymes specifically associated with fat metabolism were determined. It was thought that amino acid nitrogen of the blood would indicate if the animal had the capacity to withdraw amino acids from the blood to produce muscle tissue. High urea of the blood should be an indication of the breakdown of amino acids (loss), which would reflect poor utilization of the absorbed amino acids for growth. The heifers were all bred to the same Angus bull for two calf crops to measure their calf-producing abilities.

**Figure 3. Stall arrangement for individually feeding animals. Feed is weighed to animals and feed not eaten is weighed back twice daily. Animals are allowed three hours each feeding to eat.**

There were some indications of general combining ability, with line 1 combining well with each of the other two lines. Lines 2 and 3 did not combine well. The fact that line 1 was completely unrelated to lines 2 and 3 while 2 and 3 were somewhat related could

**Figure 4. Hereford cows and calves used in the study. All cows were inbred.**

account for a lack of increased vigor when lines 2 and 3 were combined.

The studies on blood chemical constituents, carcass measurements, and organoleptic appraisals did not reveal advantages associated with linecrossing over the inbreds.

The data on suckling gains, feed-test gains, feed per unit gain, and age at 1,000 pounds for each of the inbred lines and linecross types are presented in Table 1. It can be seen that there was no advantage of the linecrosses over the inbreds in suckling gains. It must be kept in mind that all calves, both inbred and linecross, were nursing inbred dams. Perhaps the reduced milk production of the inbred dams held the suckling gains below the potential level in both groups of calves. There was a decided advantage of linecross over inbred calves in increased feed-test gains, reduced feed per unit of gain, and reduced age at 1,000 pounds body weight.

**Table 1. Comparison of Inbreds and Linecrosses for Production Traits**

| Line | Suckling gains (lbs.) | | Feed-test gains (lbs.) | | Feed per unit gain (lbs.) | | Age at 1,000 lbs. (days) |
|---|---|---|---|---|---|---|---|
| | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ |
| 1 | 1.69 | 1.77 | 2.79 | 2.11 | 6.38 | 8.13 | 412 |
| 2 | 1.64 | 1.69 | 2.96 | 2.04 | 5.69 | 8.33 | 425 |
| 3 | 1.72 | 1.71 | 2.92 | 2.18 | 5.95 | 7.71 | 409 |
| Avg. of inbreds | 1.68 | 1.72 | 2.89 | 2.11 | 6.01 | 8.06 | 412 |
| 1 x 2 | 1.73 | 1.66 | 3.03 | 2.28 | 5.71 | 7.39 | 393 |
| 1 x 3 | 1.70 | 1.76 | 3.01 | 2.15 | 6.00 | 7.76 | 406 |
| 2 x 3 | 1.71 | 1.65 | 2.90 | 2.20 | 5.88 | 7.46 | 409 |
| Avg. of linecross | 1.71 | 1.69 | 2.98 | 2.21 | 5.86 | 7.54 | 403 |
| Advantage of linecross | +.03 | -.03 | +.09 | +.10 | +.15 | +.52 | 9 |

### Mortality of inbred and linecross calves

Perhaps the most striking advantage of the linecross calves over the inbreds was in the reduction in losses at calving. The data on calving percent and losses are presented in Table 2.

It can be seen that the only losses were at birth. There was no difference in calving percentage whether cows were producing inbred or linecross calves. The linecross calves showed markedly less loss from death at birth. Perhaps recessive genes for lethal conditions or for very low vigor at birth were present in the pure state in some of the inbred calves, while in the linecross calves most of these recessive genes were present in the heterozygous state and could not express their effects.

### Calf-producing ability

The calf-producing ability of inbred and linecross cows when all cows were mated to one and the same Angus bull is shown in Table 3. Here again, it can be noted that there was no advantage of linecross heifers over inbreds for suckling gains when both types nursed inbred dams. The linecross heifers did show an advantage over the inbreds in test gains; however, a part of this increase may be a reflection of compensatory gains due to their lower suckling gains. The important material in Table 3 is the weaning of calves produced by the inbreds and linecrosses. Here one notes that the linecross cows had calves that gained 0.12 pound and 0.07 pound per calf per day more than gains of calves by the inbred cows. These differences are attributable to the hybrid vigor of the linecross cows because all calves were crossbreds sired by the same bull.

### Associations among traits

It was of interest to see if there were any associations of traits. It was observed that larger calves at birth gained more during the nursing period, were younger at 800 pounds, and scored higher in condition and conformation. Also, calves that gained more rapidly during the nursing period reached 800

**Table 2. Reproductive Performance of Inbred Hereford Cows Bred to Produce Inbred and Linecross Calves**

| Mating | Number | Calves born* | Calves stillborn** | Total loss |
|---|---|---|---|---|
| | | % | % | % |
| Inbred | 90 | 72.2 | 13.8 | 13.8 |
| Linecrosses | 192 | 70.3 | 5.2 | 5.2 |

* Percent of calves born to cows exposed to bulls.
** Percent dead of calves born.

**Table 3. Performance of Inbred and Linecross Cows and Their Calves**

| | Dam's suckling gains | Dam's test gains | Offspring suckling gains | |
|---|---|---|---|---|
| | | | 1st calf | 2nd calf |
| | *Lbs./day* | *Lbs./day* | *Lbs./day* | *Lbs./day* |
| Inbred dams | 1.76 | 2.09 | 1.43 | 1.63 |
| Linecross dams | 1.63 | 2.28 | 1.55 | 1.70 |
| Advantage of linecross | –.13 | +.19 | +.12 | +.07 |

pounds at younger ages and scored higher in condition and conformation. The calves making more rapid gains during the feed test were more efficient in feed use and were higher in condition at 800 pounds. Conformation and condition scores were highly associated, and scores for both at 500 pounds were correlated with corresponding scores at 800 pounds body weight. Animals that required more feed per unit of gain were high in blood amino acid nitrogen, which indicated they lacked the ability to withdraw the amino acids from the blood for building muscle tissue; they consequently stored more fat and less muscle, which was biologically more expensive.

**Liver enzyme studies**

One aspect of the studies was to investigate the coenzymes associated with fat metabolism in relation to rate of gain, percent fat and lean of the carcass, and thyroid gland weight. It was found that the slower gaining calves were low in thyroid gland weight, high in the coenzymes associated with fat metabolism, low in lean percentage and high in fat percentage of the carcass. Inbred calves showed the characteristics listed above, while linecross calves had characteristics of rapidly gaining calves. Thus, our research in general indicates that rapidly gaining animals have the capacity for withdrawing amino acids from the blood for building muscle tissue. They have a high lean and low fat percentage in the carcass. They are efficient in converting feed into body weight gains.

**Pilot studies with mice**

Some pilot studies have been conducted with mice for developing and/or testing concepts that might be used in beef cattle breeding. Since progress from selection is determined largely by the genetic variation in the population and the selection method used, it seemed logical to see if genetic variation could be enhanced and if a selection method which tends to maintain genetic variation would be beneficial. To create greater genetic variation, mice were treated with 0, 25, 50, and 100 r of x-irradiation and intense selection was applied for a trait low in heritability (fertility) and a highly heritable trait (28-day weight). The results showed an increase in the genetic variation, but selection progress was much lower because of reduced fertility resulting from the irradiation treatment. Thus, it appears that genetic variation created by irradiation cannot be used because of the lowering of fertility.

A selection scheme was developed which should help to maintain genetic variation. This scheme was designated as "elite" selection. Suppose we have three traits which we are interested in improving. We could select one-third of our replacements on trait 1, one-third on trait 2, and one-third on trait 3. This should make it possible to get the most outstanding performance for each of the three traits into our replacement offspring. This method was compared with the index method in which the best replacements in overall merit (but maybe not the best in any one trait) were kept for breeding. The results of this study have not been completely analyzed, but it appears that genetic variation was maintained by the elite selection method but that progress from selection was not greater. It is assumed that, in keeping the elite animals for one of the traits, some animals were quite undesirable in the other two traits. Keeping animals with undesirable traits had a retarding effect on general progress that was equal to the enhancing effect of keeping the elite.

## Summary

1. The greatest expression of heterosis from line crossing in beef cattle was the reduction in mortality of linecross calves at, or shortly after, birth. Fertility and several other production traits were not greater in linecross than in inbred calves produced by inbred dams. There was evidence for general combining ability, in that the line 1 combined well with the other two lines. Line 2 did not combine well with line 3. Some evidence of heterosis was evident in greater rate and efficiency of gains and higher lean-to-fat ratio in linecross calves and higher suckling gains of calves produced by linecross cows. It appears that all three types of gene action are important in beef cattle. The reduced mortality at birth of the linecross calves suggests simple Mendelian inheritance. Specific combining ability and heterosis or hybrid vigor suggests overdominance or epistatic gene action. General combining ability effects suggest additive (heritable) gene control. Thus, it appears that in overall improvement of beef cattle one needs to employ production testing and progeny testing for most effective results.

2. The studies at the OSU Agricultural Experiment Station show that, although radiation appears to create more genetic variability, the reduced fertility resulting from irradiation limits selection so drastically that selection becomes relatively ineffective and, as a consequence, less improvement is made in lines in which irradiation is imposed than in control lines. The results demonstrate that females become sterile following irradiation even at relatively low dosages because of permanent ovarian damage, whereas males show no reduction in fertility and testis damage is not great or is reparable.

3. It appears that liver nicotinamide nucleotide coenzymes that are associated with fat metabolism are associated with animals with lower thyroid activity, slow rate of gain, and lower lean but greater fat deposition in the carcass. Inbreeding tended to reduce thyroid weight, rate of gain, and lean percentage and to increase fat percentage of the carcass and the coenzymes associated with fat deposit. Inbreeding may act by reducing thyroid output or by increasing enzymes affecting fat metabolism.

# Computerized Beef Cattle Improvement Programs

W. Dean Frischknecht

There are several computerized beef cattle improvement programs available to Oregon cattlemen. These recording programs make use of simple but systematic measurements of all traits having the greatest effect on the economic success of the beef cattle herd.

The first national program operating in Oregon is known as Performance Registry International and is available to all breeds of cattle, commercial as well as registered. The American Angus Association, the American Hereford Association, the American Polled Hereford Association, and the American Shorthorn Association now have similar programs which are operated by their breed affiliations. The Red Angus, Charolais, Brangus, and some other breed associations handle their computerized programs through PRI.

Each of the breed associations and PRI ask that a breeder enroll his complete cow herd in order that a true measure of productivity can be evaluated. If all females are enrolled, it is possible to obtain a measure of fertility, which is probably the most important single factor in determining profits from a breeding herd. Calving interval is readily obtained by consulting the records, which are available when all females are enrolled each year.

All of these programs are designed to measure mothering ability by obtaining calf weight and grade at weaning time. Each of these programs is specific in recommending that calves be weighed between 160 days and 250 days with an adjustment made to 205 days. This allows for all calves to be weighed within 90 days of age, and weight ratios are computed for the entire crop. Where herds are calving throughout the year, calves should still be compared to those born during each 90-day period because it is difficult to compare calves born in different seasons and raised under different feed conditions.

Each of these programs requires that a conformation score be given each calf. Calves grading Fancy or Prime are given a numerical rating of 17, 16, or 15. Calves in the Choice grade receive scores of 14, 13, or 12. Good is designated as 11, 10, 9. Calves grading below Low Good are seldom found in Oregon beef cattle herds. A grade ratio also is determined for each calf, depending upon his individual grade in comparison to the average for the herd.

Each of these programs also is designed to measure gains during the time cattle are in the feedlot. Usually, a weight is taken at the beginning of the feed test and again at the end of the designated feeding period. There are several official tests used throughout the United States wherein bulls are fed for a period of 140 days. Steer feeding programs usually commence soon after weaning and conclude when the animals have reached market weight and the desired grade.

It is now recommended in all of the breed programs and by PRI that progeny groups of a single sire be fed out and carcass information evaluated along with feedlot performance and weight per day of age. PRI asks that

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10 head by a single sire be fed out, two Hereford associations recommend a minimum of eight head, and the Angus Association recommends at least six head as constituting a progeny group. Performance Registry International will issue a certificate and designate a bull as a certified meat sire if the 10 head of progeny meet minimum specifications for doing ability and carcass merit.

As far as costs are concerned, the Angus Association program is available to all members at no extra fee. The two Hereford associations and the Shorthorn Association charge 25 cents per cow as an enrollment fee, 50 cents per calf for weaning information, and another 25 cents per animal for yearling information.

Performance Registry International has a lifetime membership fee of $50, and this money is used to defray expenses during the first year. That is, the membership fee can be used to pay the ordinary cost assessed cooperators. The complete PRI program is now available for less than $1 per cow and calf per year and a charge of 10 cents per cow for re-enrollment is made each year.

Forms for participating in any of these programs are available at the breed association offices or information can be obtained from a county Extension office. Each association asks the Extension Service to cooperate in helping breeders understand the program and to encourage full participation in a real effort to improve cattle.

Size of animals may vary among herds and breeds, but each breeder should strive for efficient production and base selection on information obtained through a complete record-of-performance program. It should be stressed that the use of records in selection will determine the amount of improvement.