EFFECT OF SELECTING FOR FRAME SIZE AND BODY TYPE ON FEED EFFICIENCY AND ECONOMIC RETURNS

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The overall goal of the beef industry should be to minimize energetic and economic costs of producing beef, so that it will be produced at a price consumers can afford and in a quantity that will meet their nutritional needs and personal desires.

Beef production is a very diverse and segmented industry in the United States, however and it is difficult to develop a coordinated effort to improve overall efficiency. Beef cows are kept in small herds (over 60% are in herds of less than 100 head) over a wide area in the U.S. to utilize those land or feed resources on farms and ranches that have little or no alternative use. Typically, the beef herd is secondary or lower in economic importance, as it is often a supplement to other farm or non-farm sources of income. Therefore, breeding systems that require time or economic resources that cannot be justified due to the size or economic importance of the herd will not be used in a large number of herds, even if overall efficiency would be improved. Beef production in the U.S. is further complicated by our system of finishing cattle. Most of our feeder cattle are gathered and transported to lots in regions where feed grains are in surplus. Therefore, it is difficult to maintain identity of cattle from superior performing herds, especially since 2/3 are placed in lots of over 1000 head capacity. To add to the confusion, it is not clear what we should select for to improve overall efficiency of beef production in the U.S. Further, priorities will vary due to location, environment and personal preferences. Therefore conclusions on selection priorities must be tempered by the variation in conditions under which beef is produced in the U.S.

There are some known relationships between body size, energy requirements, and slaughter weights that optimize energetic and economic efficiency. Also there are known relationships between traits we can measure easily (weight, height, growth rate, etc.) and feed efficiency. In the first part of this paper these relationships and how they influence overall efficiency of production will be outlined. Then some guidelines on how to use the usual information collected on breeding cattle to properly evaluate their performance will be given, based on known relationships between body size and energy requirements.

Economic Importance of Various Traits

Using current market prices, the economic value of various traits can be estimated (table 1). In most cases, the economic impact of 10% improvement in the trait was used as a basis for making some simple comparisons. It is clear that selecting for traits that relate to feed efficiency and carcass characteristics (weight, fat content and distribution) should have a high priority. These values suggest that certain carcass weights are desirable, and that we prefer beef containing some fat. This is likely justified for a variety of reasons (flavor, prevention of drying and discoloring, prevention of cold shortening, etc.)

TABLE 1. ECONOMIC IMPORTANCE OF GENETICALLY RELATED FACTORS

Trait	Difference	Value	Herit-ability	Adjusted Value
Calf crop/12 mo.[a]	90% vs. 81%	$32	10%	$3.20
Weaning weight[a]	500 vs. 450	$50	30%	$12.00
Rate of gain[b]	3.0 vs. 2.7	$ 6	50%	$3.00
Feed efficiency[b]	7.2 vs. 8.0	$24	40%	$10.00
Quality grade[c]	100% Choice vs. 50% Choice	$9.45	40%	$3.78
Yield grade[c]	100% 3's vs. 50% 4's	$12.60	30%	$3.78
Frame size[d]	Carcass over 600 lb at low choice	$ 6	60%	$3.60
	Carcass under 500 lb	$20	60%	$12.00

[a]Value of feeder calf = 80¢/lb.

[b]Value/600 lb gain. Ration cost $100/ton; non-feed cost = 28.4¢/day.

[c]Discount of $3/cwt. carcass for good vs. choice. Discount of $4/cwt. carcass for yield grade 4.

[d]Weight discounts used/cwt. carcass; 500-600, $1/cwt.; under 500, $4/cwt.

Relationship of Rate of Gain and Body Composition to Feed Efficiency

Increased rate of gain alone (assuming weight at low choice grade is not changed) simply reduces time in the feedlot, which means a lower interest, labor and use of facilities cost. The greatest benefit of an increase in daily gain is if it is also associated with a reduction in feed requirements/lb gain. Table 2 shows the relationship between daily gain, dry matter intake, feed consumed over maintenance needs, and feed requirements/lb gain. Animals of a given size with a greater daily gain can be expected to have a greater appetite and improved feed efficiency, due to a greater dilution of daily maintenance costs. Recent reviews of the literature have shown that cattle could likely be selected for greater appetite, but selection for improved digestive or metabolic efficiency would be difficult (Harpster, 1978; Reid, 1962). Therefore it follows that if daily gain is increased, dry matter intake likely increased also.

TABLE 2. RELATIONSHIP OF DAILY GAIN, FEED INTAKE AND FEED EFFICIENCY IN AN 850 LB STEER

Daily Dry Matter Intake	Daily Gain	Feed for Maintenance	Feed for Gain	Feed/gain
lb	lb	lb	lb	
15	1.82	7.5	7.5	8.24
17	2.26	7.5	9.5	7.52
19	2.68	7.5	11.5	7.09
21	3.09	7.5	13.5	6.80
23	3.48	7.5	15.5	6.61

In most studies to date in which heritability estimates for feed efficiency were determined, it is not clear whether the improvement in feed efficiency was due to a difference in appetite alone or if the composition of the gain was different as well. Energy is stored more efficiently in the body as fat than as protein; fat tissue contains 9.385 Kcal/gm, and protein contains 5.532 Kcal/gm, (Garrett, 1969). Thus less energy is required/lb of weight gain when a higher proportion is muscle rather than fat tissue, due to a lower energy concentration in protein and more water being retained in association with the protein. Therefore, before energy requirements/unit of gain can be accurate the composition of the gain must be described. Figure 1 shows the change in body composition as an animal increases in maturity. The equations that describe these relationships were developed by Reid (1978) based on a summary of body composition data available in the literature on British breed steers. This figure shows that composition of the gain changes during growth, with an increase in proportion of fat and a decrease in proportion of protein as the animal grows. When no additional protein is deposited with additional gain, the animal is chemically mature. At this point, they will store additional energy consumed above maintenance as fat, but will not deposit additional protein. Figure 2 shows the change in net energy required for 2.5 lb/day gain on an average frame steer from weaning to low choice.

Table 3 shows the weight and composition of various cattle types when fed corn grain-corn silage rations in recent trials. These studies show that animals varying in frame size are heavier at the same composition. A system of "equivalent weights" to describe the weights at which cattle of different frame sizes and sexes have a similar body composition based on these and other studies was developed (Table 4; Fox and Black, 1982). These can be used to predict energy and protein requirements at any given weight. They can also be used to estimate carcass quality and yield grade, since they are related to carcass fat content (Table 5; Fox and Black, 1982).

FIGURE 1. RELATIONSHIP OF BODY COMPOSITION TO BODY WEIGHT

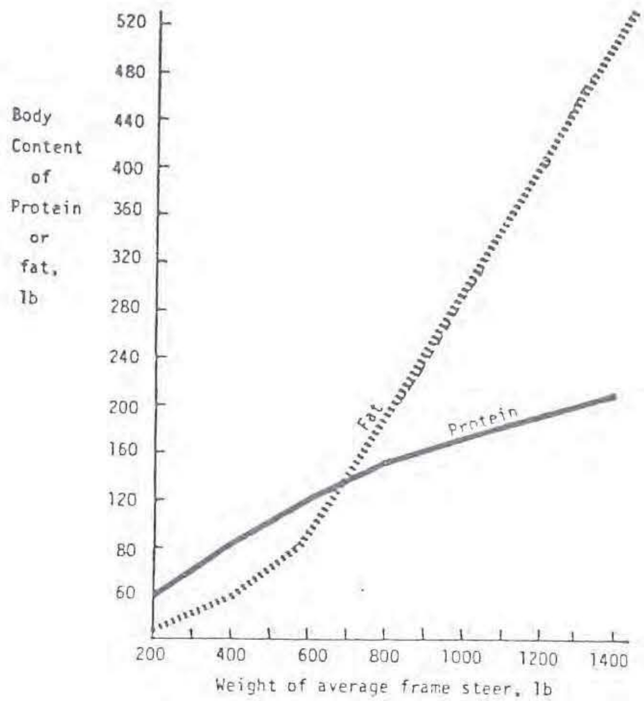


FIGURE 2. CHANGE IN NET ENERGY REQUIREMENTS AS CATTLE INCREASE IN WEIGHT

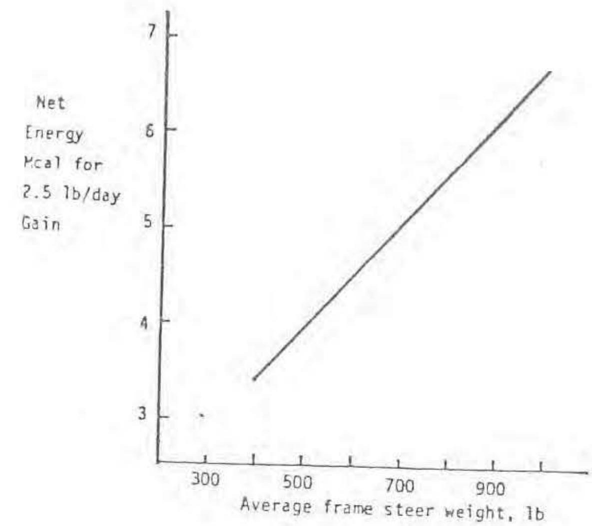


TABLE 3. WEIGHT OF DIFFERENT CATTLE TYPES AT FATNESS OF HIGH GOOD - LOW CHOICE GRADE

Trial and Cattle Type	Final Shrunk Weight, lb	Empty Body Fat, %	Carcass Quality Grade[a]	Carcass Yield Grade
Crickenberger et al (1978)				
Small Angus steers	829	28.1	9.3	2.7
Average Angus steers	937	28.0	9.9	2.8
Chianina crossbred steers	1258	24.0	8.8	2.3
Holstein steers	1232	25.2	10.6	2.7
Woody et al (1978)				
Charolais x British breed crossbred steers	1132	27.5	9.8	2.5
Hereford steers	1094	28.7	8.7	3.1
Lomas et al (1978)				
Hereford steers	961	24.1	7.9	2.8
Charolais x Hereford steers	1153	23.6	8.8	2.3
Danner et al (1978)				
Hereford heifers	838	28.7	9.1	2.7
Harpster et al (1978)				
Small Hereford heifers	750	26.5	8.9	2.4
Average Hereford heifers	887	25.7	9.1	2.7
Hereford-Angus-Charolais heifers	940	25.2	9.5	2.7
Hereford-Angus-Holstein heifers	1007	27.8	9.5	2.9
Small Hereford steers	960	29.1	9.6	2.9
Average Hereford steers	1089	30.0	9.5	3.5
Hereford-Angus-Charolais steers	1198	28.1	9.9	3.1
Hereford-Angus-Holstein steers	1214	29.4	10.2	3.5

[a] Good° = 8; Good + = 9; Choice - = 10.

TABLE 4. WEIGHTS AT WHICH VARIOUS FRAME SIZES OF GROWING CATTLE HAVE SIMILAR NUTRIENT REQUIREMENTS

	Empty body composition, %							
Fat	14.9	17.2	19.5	21.8	24.2	26.5	28.8	
Protein	19.5	19.1	18.6	18.1	17.6	17.1	16.5	
	------- Shrunk weight, lb -------							
Frame code	Steers							Breed and type
1	400	480	560	640	720	800	880	Small-frame British
2	425	510	595	680	765	850	935	
3	450	540	630	720	810	900	990	
4	475	570	665	760	855	950	1045	Average-frame British
5	*500*	*600*	*700*	*800*	*900*	*1000*	*1100*	
6	525	630	735	840	945	1050	1155	Large-frame British
7	550	660	770	880	990	1100	1210	Average-frame European
8	575	690	805	920	1035	1150	1265	British x European
9	600	720	840	960	1080	1200	1320	Large-frame European, Holstein
	Heifers							
1	320	385	450	510	575	640	705	Small-frame British
2	340	410	480	540	610	680	750	
3	360	435	510	575	645	720	795	
4	380	455	535	610	685	760	840	Average-frame British
5	*400*	*480*	*560*	*640*	*720*	*800*	*880*	
6	420	500	585	670	755	840	920	Large-frame British
7	440	525	610	705	790	880	965	Average-frame European
8	460	550	640	735	830	920	1010	British x European
9	480	575	670	770	865	960	1055	Large-frame European, Holstein
	Bulls							
1	480	575	670	770	865	960	1055	Small-frame British
2	510	610	715	815	920	1020	1120	
3	540	650	755	865	970	1080	1190	
4	570	685	800	910	1025	1140	1255	Average-frame British
5	*600*	*720*	*840*	*960*	*1080*	*1200*	*1320*	
6	630	755	880	1010	1135	1260	1385	Large-frame British
7	660	790	925	1055	1190	1320	1450	Average-frame European
8	690	830	965	1105	1240	1380	1520	British x European
9	720	860	1010	1150	1300	1440	1585	Large-frame European, Holstein

TABLE 5. ESTIMATED CARCASS QUALITY AND YIELD GRADE

Empty Body, % Fat	Carcass, % Fat[a]	Quality Grade[b]	Yield Grade[c]
25.6	28.5	Good +	2.2
26.9	29.8	Good +	2.5
28.1	31.2	Good +	2.8
29.3	32.5	Choice -	3.1
30.6	33.8	$\geq$ Choice -	3.4
31.8	35.2	$\geq$ Choice -	3.7
33.0	36.5	$\geq$ Choice -	4.0
34.2	37.8	$\geq$ Choice -	4.3

[a] Garrett and Hinman, 1969. Carcass fat = .7 + 1.0815 (empty body fat). R^2 = .98.

[b] Fox and Black, 1977. Quality grade = 2.5 + .23 (carcass fat) for a range of 15 - 38% carcass fat. $Good^o$ = 8, $Choice^-$ = 10. Accounted for 62 - 72% of the variation in quality grade over the data base used (Crickenberger et al, 1978; Madamba, 1966; Riley, 1969).

[c] Yield grade = .15 (% carcass fat) - 1.7.

Using this system, expected performance of cattle of different frame sizes at varying initial and final weights can be predicted and compared. A scale of 1 - 9 was devised to correspond to different weights of cattle at the same composition. This range was chosen rather than the commonly accepted Missouri scale of 1 - 7, to correspond to the 9 USDA feeder calf grades. A frame score "5" is similar to a Missouri frame 4 and a "9" is similar to the Missouri frame score 7. Table 5 compares the predicted performance of small (frame 1), average (frame 5) and large (frame 9) steers from "equivalent" initial weights to a fatness of 28% body fat, which would correspond to low choice - yield grade 3. The larger steers have a heavier average weight, and therefore a higher maintenance requirement. They also consume more feed. The energy requirements/unit gain is the same. The daily gain is greatest for the large cattle but not relative to their average weight. Thus gain/unit of average metabolic body size (relative gain) would have to increase to improve feed efficiency. The predicted relative performance of the different frame sizes agrees closely with the results of Klosterman and Parker (1976), Brungardt (1972), Smith et al. (1976a), and Crickenberger et al. (1978).

In the studies of Smith et al. (1976), efficiencies to equal fatness only varied from 20.6 to 22.1 MCal ME/kg gain across 1105 steers from Hereford, Angus, Jersey, South Devon, Limousin, Charolais and Simmental sires. Crickenberger et al. (1978) found that MCal ME required per kg edible portion gain only varied from 55.2 to 57.1 across small and average size Angus and Angus X Chianina crossbred. However, Holsteins required 72.1 MCal ME/kg edible portion. An extensive review of the literature (Fox and Black, 1982) indicate that while differences in feed efficiency are small across a wide variation in beef breed cattle, Holstein steers may be an exception.

A computerized performance simulation program was developed to predict daily gain, feed intake, total feed requirements, carcass grades, cost of gain and profits of different cattle types under different environmental conditions (Fox and Black, 1982). Current feed costs, non-feed costs (interest, medical transportation, facilities, etc.), death loss and shrink, feeder and finished cattle prices and price differentials for different grades are entered along with the frame size, sex, environment, feed additives and growth stimulants used, and ration composition fed during different periods. It should be noted here that larger frame cattle have a higher daily non-feed cost, due to a greater initial cost because of their greater weight, which increases interest and death loss cost/head. Also more space is required because of their larger size, and more feed and manure is handled/head. Crickenberger and Black (1976) discussed these costs in detail. Therefore, most non-feed costs are proportional to size. Field testing of this program was conducted to determine its accuracy and usefulness. These field observations have been summarized (Fox and Black, 1982; Minish and Fox, 1982). One of the uses is to compare the optimum slaughter weight of different cattle types and different combinations of cattle, feed and non-feed prices.

TABLE 6. PERFORMANCE NEEDED BY CATTLE DIFFERING IN FRAME SIZE TO ACHIEVE EQUAL FEED EFFICIENCY

	Frame Size		
	Small	Average	Large
Equivalent initial weight, lb	400	500	600
Weight at low choice, lb	880	1100	1320
Average weight while on feed, lb	640	800	960
Daily net energy for maintenance, Mcal	5.47	6.47	7.41
Net energy/lb gain, Mcal	2.11	2.11	2.11
Expected daily intake, lb	14.0	16.5	18.8
Relative intake, gm/$W_{kg}^{.75}$	89	88	87
Equivalent daily gain, lb	2.20	2.60	3.00
Relative gain, gm/$W_{kg}^{.75}$	14	14	14

Table 7 compares expected profitability of frame size 5 and 9 steers at the same weight and at the same grade, at current prices (see footnotes to table 1.) At the same weight, the large frame steer has a faster rate of gain, and lower feed/lb gain due to less fat in the gain. However, it would also have a lower quality grade and at current discounts for the good grade, would be $77.60 less profitable/head. Even if the price for good and choice were equal, the larger frame steer may not be as profitable fed to the same weight due to less dilution of fixed "start up" costs (procurement, transportation, death loss, etc.). At the same grade, however the large steer returns a similar profit/lb gain or more/head because of more weight gain. Thus the cattle feeder could use either type to produce a given amount of gain. However, any discounts for carcass weight (light or heavy) or for breed effects on fat distribution must be included in the prices used for the finished cattle.

TABLE 7. IMPACT OF SLAUGHTER WEIGHTS ON PROFITS

Frame	Shrunk Weight lb	Daily Gain lb	Feed/ Gain	Quality Grade	Yield Grade	Sale Price $/cwt.	Net Return /Head $
Average	1050	2.34	6.94	C -	3.1	78.0	+ 38.40
Large	1050	2.63	6.52	Gd +	2.1	76.20	- 39.20
Large	1250	2.67	6.96	Ch -	3.1	78.0	+ 47.40

The Effect of Selection for Growth Rate and Cattle Type on Returns to the Beef Herd, Cattle Feeder, or to the Entire System of Beef Production

Almost no data has been reported on the impact of selection for growth rate on feed and energetic efficiency, where the resulting calves were fed to the same final carcass composition. To provide some information on this effect, feeding trials were conducted with the cows and calves from a selection study at Michigan State University. The results of this study have been reported by McPeake (1977) and Harpster *et al* (1978). (For the literature reviews and complete details, it is suggested that the Ph.D. theses of Charles McPeake (1977) and Harold Harpster (1978) be obtained from University Microfilms, Ann Arbor, Michigan).

To initiate this study, 200 Hereford cows were divided into 4 herds of 50 cows each. The mating system used for each herd was: random, (unselected Herefords, USH); selection for yearling weight (selected Herefords, SH) selection for yearling weight and 3 breed rotation with Hereford, Angus and Charolais (AHC) and 3 breed rotation with Hereford, Angus and Holstein (AHH). The first matings were made in 1967; the first calves were obtained from F_1 dams in 1970. Table 8 shows the impact on the cow herd of each breeding system. One of the effects was to increase cow size. Additional weaning weight was obtained above that expected for the change in cow weight, due to selection and/or the differential between sire and dam mature size. With only a 20% replacement rate, it will take several years more for average cow size to reach the same level as the sires used. There was an additional benefit due to crossbreeding, agreeing with the results of many others. This effect was improved fertility and likely increased milking ability of the dams. Under conditions of this study, feed efficiency/lb weaning weight improved by all three practices; selection, crossbreeding, and use of dairy breeding to increase milk production.

TABLE 8. IMPACT OF SELECTION AND CROSSBREEDING ON FEED REQUIREMENTS OF BEEF HERD[a,b]

	Unselected Hereford	Selected Hereford	Hereford Angus Charolais	Hereford Angus Holstein
Cow weight[c]	873	933	1001	999
Individual weaning weight, lb	408	454	514	551
Additional due to				
Cow frame size	-	11	22	22
Selection + bull-cow differential size	-	35	35	35
Crossbreeding	-	-	49	86
Feed DM/cow unit, Tons	4.84	5.00	5.33	5.44
% weaned	80	80	85	90
Average salable calf weaning wt., lb	326	363	437	496
Cull cow weight sold/yr.	174	186	200	200
Feed/lb weight sold/yr.	19	18	17	16

[a]McPeake, 1977; Harpster, 1978.

[b]Includes data from 1972-1976 calf crops.

[c]Taken at weaning in the fall.

The next step was to determine the value of the calves to the cattle feeder. At weaning, for 3 years steer calves produced from each herd were placed on high corn silage or high corn grain rations. In two of these 3 years, heifers not saved for replacements were fed on a high silage ration to compare with steers from the same herd fed the same ration. Table 9 compares the performance of the heifers not saved for replacements with steers fed an all corn silage ration to the same degree of fatness. The first change is an increase in carcass weight at a small degree of marbling. If a 600 lb carcass is the minimum accepted without discount, then steer weight from the same herd was over 1250 lb so that heifer mates were near 1000 lb at a small degree of marbling, yield grade 3, 29% carcass fat. Actual daily gain and intake increased with cattle size, but relative gain was similar across all types and both sexes, supporting the basic principles discussed previously. Differences in feed requirements between steers and heifers within each breeding group were small, but heifers consistently required about 2% more feed/lb gain. Feed requirements were higher for the crossbred steers and heifers, however.

TABLE 9. EFFECT OF SELECTION AND CROSSBREEDING ON PERFORMANCE OF STEERS AND HEIFERS FED AN ALL CORN SILAGE RATION[a]

		Unselected Hereford	Selected Hereford	Hereford Angus Charolais	Hereford Angus Holstein
Carcass weight, lb	Steers	587	664	730	766
	Heifers	466	550	583	625
Adjusted final live weight, lb[b]	Steers	970	1098	1207	1266
	Heifers	770	909	964	1033
Daily gain, lb	Steers	2.00	2.20	2.31	2.35
	Heifers	1.65	1.85	1.98	2.00
Relative gain, gm	Steers	12	12	12	12
	Heifers	12	12	12	12
Dry matter intake, lb	Steers	15.7	17.8	19.0	20.3
	Heifers	13.5	15.7	16.8	18.2
Relative intake, gm	Steers	96	99	99	101
	Heifers	100	103	103	104
Feed/100 lb gain	Steers	786	828	847	857
	Heifers	805	847	866	876
Marbling[b]	Steers	small	small	small	small
	Heifers	small	small	small	small
Yield grade[b]	Steers	2.6	3.0	3.0	3.2
	Heifers	2.0	2.4	2.3	2.6

[a]Harpster, 1978. Two-year summary.

[b]Final weights, performance and carcass data adjusted to equal dressing percentage and to 29.2% carcass fat.

Table 10 summarizes three years of comparisons between each of the types of steers fed high silage or high grain rations. Daily gains increased with body size but relative gain did not. It is clear that relative gain could be increased by feeding more grain but not by increasing frame size. Feed requirements/100 lb gain were not different between unselected and selected steers fed either ration. However, those steer calves from crossbred cows had higher feed requirements. Note that carcass marbling, grade and fatness were not very different between cattle types. However, those fed high grain rations consistently contained more fat and had poorer yield grades, even though marbling was not improved by feeding a high grain ration. Similar results have been obtained in other trials recently (Crickenberger et al, 1978; Danner et al, 1978; Woody et al, 1978). It should be noted here that the gains and feed requirements obtained in this study for the different cattle types agree closely with those predicted by the performance simulator described earlier.

TABLE 10. EFFECT OF SELECTION AND CROSSBREEDING ON STEERS FED ALL CORN SILAGE OR HIGH GRAIN RATIONS[a]

	Unselected Hereford	Selected Hereford	Hereford Angus Charolais	Hereford Angus Holstein
Final carcass weight, lb	601	691	763	774
Adjusted final live weight, lb	974	1120	1237	1254
Carcass fat, %				
High silage	30	31	29	30
High grain	34	35	33	35
Marbling Score				
High silage	small	small	small	small
High grain	small	small	small	modest
Yield grade				
High silage	2.7	3.2	2.9	3.3
High grain	3.1	3.6	3.3	3.7
Daily gain, lb				
High silage	1.89	1.98	2.29	2.22
High grain	2.51	2.79	2.90	2.84
Relative gain, gm				
High silage	12	12	11	11
High grain	15	15	15	14
Dry matter intake, lb				
High silage	15.8	17.9	19.4	20.0
High grain	15.4	17.5	19.0	19.6
Relative intake, gm				
High silage	97	100	98	100
High grain	93	96	95	96
Feed/100 lb. gain				
High silage	847	851	877	887
High grain	609	614	639	726

[a]Harpster, 1978. Three-year summary of feeding trials.

Using the data shown in Tables 9 and 10 the value/lb of the steers and heifers from each type to a cattle feeder was calculated (Table 11). The footnotes show the assumptions used to make these calculations. The crossbred steers were worth less than the straight breed steers because of their higher feed requirements. The advantage of the crossbred heifers in carcass weight was offset by their lower feed efficiency. Other studies have shown the negative relationship between maternal ability of the dams and feedlot performance of the calves.

This study shows that producing cattle that improve beef herd performance will not necessarily improve returns for the cattle feeder. The breeding system that will likely prevail is one that is best overall, considering all segments. The overall profitability of each breeding system is summarized in Table 12. This table compares the returns/250 tons of feed available for a beef herd. The crossbred herd is the most profitable overall primarily due to improved percent calf crop weaned. The selected steers are more profitable than the unselected, primarily due to cow size not having caught up to the mature size of the selected bulls used, thus reducing feed costs relative to the weaning weight produced. Additionally, a heavier carcass was produced, avoiding carcass weight discounts.

TABLE 11. RELATIVE VALUE OF FEEDER CALVES TO A CATTLE FEEDER[a]

	Unselected Hereford	Selected Hereford	Hereford Angus Charolais	Hereford Angus Holstein
Choice @ 50¢				
Steers, $/lb	.49	.49	.48	.44
Heifers, $/lb	.42	.43	.44	.42
Choice @ 80¢				
Steers, $/lb	1.19	1.21	1.14	1.12
Heifers, $/lb	1.05	1.13	1.09	1.05

[a]Ration cost @ $100/ton, DM, nonfeed costs @ 11¢/lb gain + 3¢/lb gain feedlot profit. Discounts @ 80¢ steers: Steers < 1000 lb, 1¢; Heifers < 830 lb, 4¢; Heifers 830 - 920, 3¢; Heifers 920 - 1000, 2¢. Discounts @ 50¢ steers: Heifers < 830, 3¢; Heifers 830 - 920 2¢; 920 - 1000, 1¢.

TABLE 12. GROSS RETURNS/250 TONS BEEF HERD FEED[a]

	Unselected Hereford	Selected Hereford	Hereford Angus Charolais	Hereford Angus Holstein
Cattle sold/year				
% Steers	40	40	42.5	45
% Heifers	20	20	22.5	25
% Cull cows	20	20	20	20
Weight marketed/cow unit				
Steers, lb	392	442	517	574
Heifers, lb	155	183	219	260
Cull cows, lb	174	186	200	200
Returns/cow unit, $				
Steers @ 50¢	163	179	215	225
Steers @ 80¢	367	413	485	528
Beef herd units kept	51.6	50	46.9	46.0
Returns for herd, $				
Steers @ 50¢	8431	8931	10068	10355
Steers @ 80¢	18372	20647	22753	24265

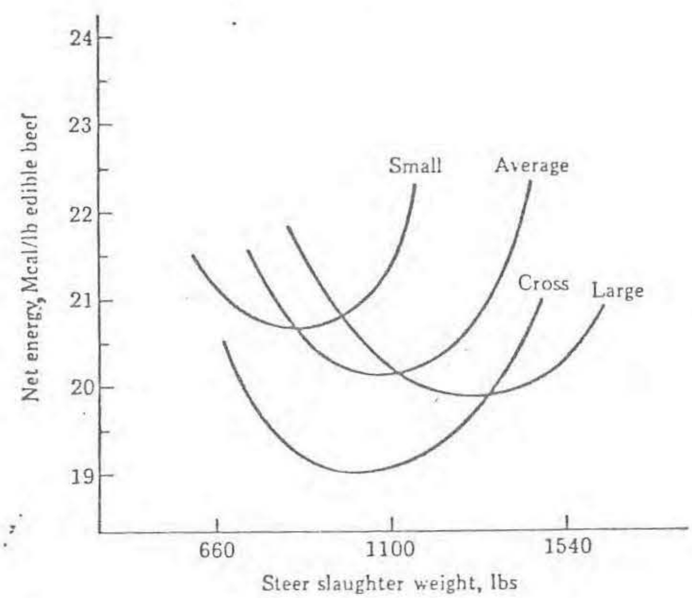
[a]Feed purchased to finish calves from weaning to slaughter. Ration cost @ $100/ton DM, nonfeed costs @ 11¢/lb gain + 3¢/lb gain feedlot profit. Discounts @ 80¢ steers: Steers < 1000 lb, 1¢; Heifers < 830 lb, 4¢; Heifers 830 - 920, 3¢; Heifers 920 - 1000, 2¢. Cows @ 70% of steer price. Discounts @ 50¢ steers: Heifers < 830, 3¢; Heifers 830 - 920, 2¢; 920 - 1000, 1¢. Cows @ 60% of steer price.

A System for Evaluating Breeding Cattle for Improved Efficiency

It is clear that any system for evaluating breeding cattle for improved efficiency must take into account carcass weight needed, stage of growth and composition of gain, and maintenance cost. Also any effect on age at puberty and re-breeding performance must be taken into account. A logical approach to evaluating breeding cattle for efficiency of production based on the physiological and nutritional principles and data presented earlier would be as follows:

1. Select the live weight wanted at a given chemical composition. Figure 3 shows that the most efficient point is to slaughter the calves when they reach approximately 26% body fat (slight marbling, yield grade 2 - 2½). Included are maintenance costs of the breeding herd and energy costs of growth and maintenance post-weaning. We now slaughter them at an average of about 29% body fat (small marbling, yield grade 2½ - 3).

FIGURE 3. IMPACT OF STEER SLAUGHTER WEIGHT ON ENERGETIC EFFICIENCY[a]



[a]Fox and Black, 1975.

We may reduce fat requirements in the future as new technology is developed in slaughter, handling and cooking procedures, allowing us to slaughter at the most efficient point. Table 4 can then be used to determine the frame size needed. For example, assuming a minimum 600 lb carcass and maximum 750 lb carcass weight, frame size 6 - 8 cattle would be best for the industry as a whole (Missouri frame 4 - 6). Using this approach, the optimum size can be selected for each beef marketing situation.

2. Feed heifer and bull calves on a standardized medium energy ration post-weaning to near 365 days of age. Make evaluations at this point, so that enough time is allowed for equalization for pre-weaning environment. Obviously calves that were sick for an extended period during either the pre-weaning or post-weaning period cannot be compared with each other, nor can those that were in an environment where severe nutritional stress occurred. However, those receiving less milk and/or grass will likely compensate on a 140-160 day post-weaning test ration, if they are equal in growth potential.

3. At 365 days:

A. Use the best system available to estimate frame size. (Currently hip height and the Missouri system are being used). Then ratio daily gain of cattle (365 day weight and 140 day test gain) within frame sizes.

<u>or</u>

B. Enter the initial weight, final weight, and ration into the performance simulator to estimate average expected performance, which can be divided into actual performance to estimate an efficiency ratio, to allow comparison across frame sizes.

Table 13 gives an example of how average expected weights for various frame sizes of bulls and heifers at 365 days can be predicted, based on expected weaning weights and performance. These tables were developed by entering the frame size, equivalent 205 day weaning weight, and indicated energy level for the ration into the performance simulation program. It was assumed that the calves were fed in a no stress environment during the post-weaning feeding period, and no growth stimulant was given to the heifers. Thus if an animal exceeds these weights within a frame size, it would be above average for the population within that frame size, and would likely have an improved feed efficiency due to a greater daily feed intake and dilution of maintenance requrirements, as discussed earlier. This approach may be as accurate as determining actual feed intake, if adjustments are not made for stage of growth.

Within each frame size, the expected mature weight is given. These are estimates, using extrapolations of the growth curves described earlier.

Table 14 gives example comparisons of bulls fed at the Cornell Bull Test in 1978-79. The first comparison is between the four bulls with the highest daily gain on test. The Angus bull gaining 3.94 was clearly more efficient than the others. However, the other Angus and the Simmental bull were no different in efficiency, even though their daily gains were different, due to the difference in frame size. The Chianina was above average expected for the ration and his frame size, but was not as efficient as the others. In the next comparison, the faster gaining Hereford was not likely more efficient than the slower gaining Hereford, due to differences in frame size. However, in the next comparison, the fastest gaining Simmental would clearly be superior as the frame size was equal.

TABLE 13. EXPECTED AVERAGE 365 DAY WEIGHTS FOR HEIFERS AND BULLS FED DIFFERENT ENERGY LEVELS POST WEANING

	Frame Size[a]						
	1	2	3	4	5	6	7
	Expected mature weight[b]						
Cows	880	950	1025	1100	1175	1245	1320
Bulls	1460	1585	1706	1830	1955	2076	2200
	Expected average adjusted 205 day weaning weight[c]						
Male calves	420	445	470	495	520	545	570
Female calves	355	375	400	420	440	460	480
	Expected 365 day weight for heifers, lb[d]						
Ration TDN, % in DM							
63	485	515	540	570	600	630	655
66	515	545	575	605	635	665	690
70	545	575	610	640	670	705	735
	Expected 365 day weight for bulls, lb[d]						
Ration TDN, % in DM							
70	710	750	790	830	870	910	945
75	770	815	860	900	945	985	1020
80	820	865	910	960	1005	1050	1090

[a]Missouri frame score.

[b]Cows assumed to be in average condition (weight:height ratio of 3.9 kg. body weight/cow height at hooks; Klosterman and Parker, 1976).

[c]Assumes average adjusted 205 day weight/kg cow weight $^{.75}$ of 2.13 kg for males and 1.80 kg for females, based on data of McPeake (1977).

[d]Weights assumed to be after 16 hours without feed and water. Add 4% to expected weight if shrunk weight not used. Assumes a no stress environment, and no growth stimulant used.

The 365 day ratios should be the most useful, as any differences in preweaning nutrition and condition would tend to be equalized.

The program and standards proposed here are only suggested as a means of evaluating an animal's performance. Bulls and heifers must be proven to see if they have the ability to transmit these traits, and further research is needed to determine the heritability of feed efficiency to the same composition.

TABLE 14. COMPARISON OF BULL PERFORMANCE-1979 TEST - CORNELL

Breed	Initial Weight	Final Weight	Daily Gain	Frame Score[a]	140 Day Test Actual/ Predicted Gain[b]	Actual/ Predicted 365 Day Weight[c]
Angus	589	1141	3.94	5	1.35	1.10
Simmental	591	1109	3.70	6	1.27	1.12
Angus	483	977	3.53	3	1.28	0.79
Chianina[d]	902	1380	3.41	9	1.13	1.11
P. Hereford	601	1047	3.19	5	1.09	1.05
P. Hereford	621	998	2.69	2	1.08	1.06
Simmental	591	1109	3.70	6	1.27	1.12
Chianina	553	980	3.05	6	1.05	0.90

[a]Missouri frame score.

[b]Performance simulation program of Fox and Black (1982) used to determine expected gain, based on initial and final weight, frame size and ration energy level.

[c]Actual 365 day weight = adjusted 205 day weight +(post-weaning test daily gain x 160). Predicted weight taken from Table 13, with 4% added, as full weight used for final off test weight.

[d]Projected from Missouri frame score system.

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