PROCEEDINGS

BEEF IMPROVEMENT FEDERATION

RESEARCH SYMPOSIUM & ANNUAL MEETING

May 21-22-23, 1979
Lincoln Hilton Hotel
Lincoln, Nebraska

PROCEEDINGS OF BEEF IMPROVEMENT FEDERATION

RESEARCH SYMPOSIUM AND ANNUAL MEETING

Table of Contents

Topic	Page	Color
Program for 1979 Meeting	1	Light Green
RELATIONSHIP OF GROWTH RATE AND FRAME SIZE TO FEED EFFICIENCY AND ECONOMIC RETURNS - Dr. Danny G. Fox	3	Canary
GENETIC VARIATION IN FEED EFFICIENCY - Dr. M. K. Nielsen	21	Light Blue
APPLICATION OF FEED EFFICIENCY KNOWLEDGE - Dr. E. L. Lasley	28	Salmon
WHY USE LINEAR MEASUREMENTS - Dr. A. L. Eller, Jr.	51	Buff
HOW WE USE LINEAR MEASUREMENTS - Mr. Burke Healey	60	Goldenrod
INHERENT DANGERS OF LINEAR MEASUREMENTS - Dr. Robert C. de Baca	73	Pink
PRESIDENT'S ADDRESS - Dr. James A. Bennett	86	Light Green
MINUTES OF BOARD OF DIRECTORS MEETINGS AND FINANCIAL STATEMENT	89	Canary
BIF AWARDS PROGRAM	96	Salmon
ATTENDANCE AT 1979 BIF CONFERENCE	104	Buff

BEEF IMPROVEMENT FEDERATION

ANNUAL CONVENTION

May 21-22-23, 1979

Lincoln Hilton Hotel
Lincoln, Nebraska

Monday, May 21

7:45 - 9:00 a.m. REGISTRATION

6:30 - 9:00 a.m. BIF Board Meeting

9:00 - 12:00 noon SYMPOSIUM I - FEED EFFICIENCY
Dr. Robert Koch, University of Nebraska & USMARC, Clay Center, Nebraska, Chairman

A. RELATIONSHIP OF GROWTH RATE AND FRAME SIZE TO FEED EFFICIENCY AND ECONOMIC RETURNS
- Dr. Danny G. Fox, Cornell University, Ithaca, New York

B. GENETIC VARIATION IN FEED EFFICIENCY
- Dr. Merlyn Nielsen, University of Nebraska, Lincoln, Nebraska

C. APPLICATION OF FEED EFFICIENCY KNOWLEDGE
- Dr. Earl Lasley, Farmers Hybrid Co., Inc., Des Moines, Iowa

10:30 - 10:45 a.m. Coffee Break

12:00 noon RECOGNITION LUNCHEON - James A. Bennett, Red House, Virginia, BIF President, Presiding

Welcome

Recognition of Award Nominees for Commercial Producer and Seedstock Producer of the Year

1:30 - 4:30 p.m. TRAIT COMMITTEE MEETINGS

Reproduction - Bill Durfey, Chairman
Carcass Evaluation - Greg Martin, Chairman
Live Animal Evaluation - Dick Spader, Chairman
Growth & Efficiency of Gain - Jack Farmer and Ken Ellis, Chairmen

3:00 - 3:15 p.m. Coffee Break

4:30 p.m. ELECTION DIRECTORS

- Regional Caucuses
- General Meeting for At Large Director Election

6:30 p.m.	AWARDS BANQUET - Master of Ceremonies, Dr. Frank Baker

National BIF Awards

- Pioneer Awards
- Continuing Service Awards
- Beef Cattle Improvement Association of the Year
- Commercial Producer of the Year
- Seedstock Producer of the Year

<u>Tuesday, May 22</u>

8:30 - 11:00 a.m. SYMPOSIUM II - LINEAR MEASUREMENTS
Ken Ellis, Western Regional Secretary, Davis, California, Chairman

A. WHY USE LINEAR MEASUREMENTS?
- Dr. A. L. Eller, Jr., VPI & SU, Blacksburg, Virginia

B. HOW WE USE LINEAR MEASUREMENTS
- Mr. Burke Healey, Davis, Oklahoma

C. INHERENT DANGERS OF LINEAR MEASUREMENTS
- Dr. Robert C. de Baca, Huxley, Iowa

9:45 - 10:00 a.m. Coffee Break

11:30 a.m. LUNCHEON - Mr. Mark Keffeler, Sturgis, South Dakota, BIF Vice-President, Presiding

President's Comments - James A. Bennett

2:00 - 3:30 p.m. PROGRAM COMMITTEE MEETINGS

- Seedstock Committee - Dr. Craig Ludwig, Chairman
- Commercial Herd Committee - Mark Keffeler, Chairman
- Central Test Committee - Tom Shaw, Chairman
- Sire Evaluation Committee - Dr. Larry Cundiff, Chairman

3:30 - 4:00 p.m. COMMITTEE REPORTS - Dr. Dixon Hubbard

<u>Wednesday, May 23</u>

7:00 - 11:00 a.m. BIF Board of Directors Meeting

RELATIONSHIP OF GROWTH RATE AND FRAME SIZE TO FEED EFFICIENCY AND ECONOMIC RETURNS[1]

Danny G. Fox
Cornell University, Ithaca, New York

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

[1] Invited paper presented at Beef Improvement Federation Annual Meeting, Lincoln, Nebraska, on May 21, 1979.

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%	$40	10%	$ 4.00
Weaning weight[a]	500 vs. 450	50	30%	15.00
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	6.00	60%	3.60
	Carcass under 500 lb	20.00	60%	12.00

[a]Value of feeder calf = $1/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 (lb)	Daily Gain (lb)	Feed for Maintenance (lb)	Feed for Gain (lb)	Feed/Gain
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

FIGURE 1. RELATIONSHIP OF BODY COMPOSITION TO BODY WEIGHT

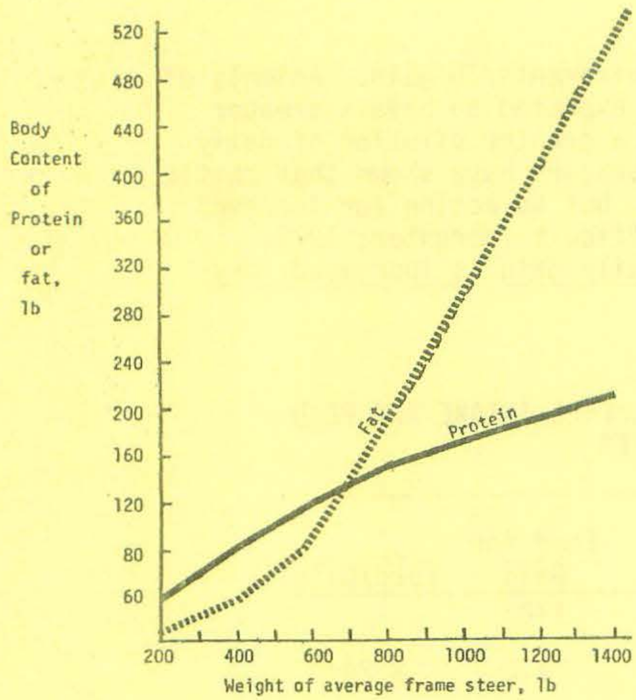


FIGURE 2. CHANGE IN NET ENERGY REQUIREMENTS AS CATTLE INCREASE IN WEIGHT

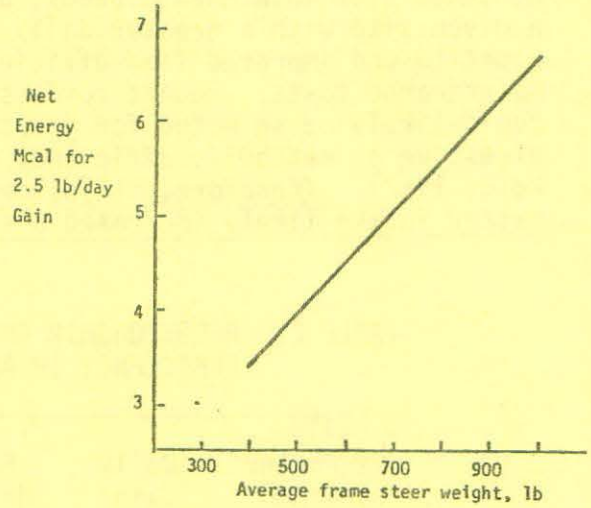


TABLE 3. WEIGHT OF DIFFERENT CATTLE TYPES AT FATNESS OF HIGH GOOD - LOW CHOICE GRADE

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^{0} = 8; Good + = 9; Choice - = 10.

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, 1977). 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, 1977).

Using this sytem, expected performance of cattle of different frame sizes at varying initial and final weights can be preciged 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 reduce the error in estimating requirements. 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), and Smith (1976).

Using this system 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, 1977). 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, 1977; Minish and Fox, 1979). 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 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	≥ Choice -	3.4
31.8	35.2	≥ Choice -	3.7
33.0	36.5	≥ Choice -	4.0
34.2	37.8	≥ 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.

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 Impact of Selection for Yearling Weight 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 yearling weight 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 on 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 relationships 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 prrimarily 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

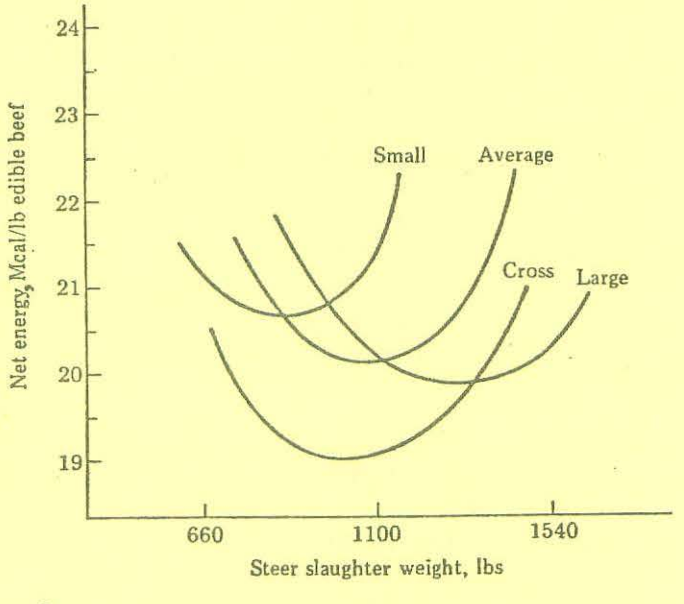
[a]Feed purchased to finish calves from weaning to slaughter. Ration cost @ $100/ton DM, nonfeed costs @ 11¢/lb gain + 3¢/lb gain feedlot profit. Discounts @ 80¢ steers: Steers < 1000 lb, 1¢; Heifers < 830 lb, 4¢; Heifers 830 - 920, 3¢; Heifers 920 - 1000, 2¢. Cows @ 70% of steer price. Discounts @ 50¢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

or

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 requirements, 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 gastest 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 (1977) 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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Genetic Variation in Feed Efficiency [1]

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Identification of genetic variation in any economically important characteristic of cattle would open discussion of opportunities for improvement through breeding programs. If additive genetic variation is present, selection would be the tool to use; if non-additive genetic variation is present, then some method of systematic crossbreeding could be used effectively. Genetic variation in feed efficiency could be examined in many phases of the production cycle: growth of young animals, gestation or lactation of dams, etc. This discussion centers on genetic variation in feed utilization of young growing animals. But we must recognize that full production cycle efficiency is more complex and important (Dickerson, 1978).

Measurement of feed efficiency of the growing animal over some interval may come in many forms. The traditional measure of efficiency is feed/gain; however the reciprocal (gain/feed) or nutrient intake relative to gain (TDN/gain) or energy intake relative to gain (Mcal/gain) may be used. All the above definitions are related and would rank a group of animals the same. From an energy balance standpoint, efficiency could be represented as energy intake/energy stored, or especially for meat producing animals like beef cattle as energy intake/protein energy stored. All the definitions mentioned are biological not necessarily economic definitions. Feed/gain will be used in this discussion for ease of understanding.

Interval of measurement can take on many forms. Measurement of feed efficiency on a growing animal has usually taken place postweaning, e.g. during gain test for a young bull. Possible intervals for measurement could be: time constant interval (e.g. 140 days), weight constant interval (e.g. 600-1000 lbs), maturity constant interval (e.g. 12%-22% fat in carcass) or some combination of these. For comparing animals that are in a contemporary group, the time constant interval is the easiest; you simply record feed intake and gain during the same period of time. The weight constant interval measurement would require some adjustments for making comparisons within a contemporary group of animals since the animals would vary in their starting and finishing weights within the common time period of measurement. As an alternative, if animals had their feed data recorded over the same weight interval they would vary in their starting and finishing dates and thus be exposed to more environmental variation. From weight constant interval measurement, adjustment to a constant weight interval of data collected during a contemporary time interval is the preferred procedure.

Measurement of feed efficiency over a maturity constant interval has appeal since we usually slaughter our steers and heifers at some "relative" maturity point in their growth. Thus some measure of feed efficiency up to that maturity point should be useful for comparison purposes. Research workers have made the most use of maturity constant endpoints in evaluating different breed groups and

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sizes of cattle. However, use of maturity constant interval data collected on individual animals for use in selection decisions is probably limited at the present time. Accuracy of evaluation of stage of maturity on the live animal coupled with either contemporary data collection and accompanying adjustments to a maturity interval or non-contemporary data collection are some of the reasons for limiting the effectiveness of these data in breeding cattle comparisons.

Partitioning Feed/Gain

Feed in the numerator of Feed/Gain can be partitioned into the component for maintenance of the animal and the component for gain as follows:

$$\frac{\text{Feed}}{\text{Gain}} = \frac{\text{Feed for Maintenance} + \text{Feed for Gain}}{\text{Gain}}$$

$$= \frac{\text{Feed for Maintenance}}{\text{Gain}} + \frac{\text{Feed for Gain}}{\text{Gain}}$$

Feed for Gain is only the feed intake which is directly used for new tissue growth and increase in weight. Feed for Maintenance is the feed intake utilized in all other body functions to keep the animal alive and fit in its enviornment, maintain its health, support its level of activity, etc.

Over any interval of measurement, Gain can be expressed as the product average daily gain (ADG) times days (D) or Gain = ADG x D. Feed for Gain can be expressed as the product of Gain times the partial efficiency of food utilization for gain. This partial efficiency is the ratio of the number of units of feed just utilized for gain per unit of gain attained. This ratio can also be thought of as the food to create gain (FCGR) ratio. Thus, Feed for Gain = ADG x D x FCGR.

Feed for Maintenance is dependent upon many variables, one of which is the weight of the animal. For ease of representation, Feed for Maintenance will be expressed as a function of weight maintained with recognition and inclusion of other factors influencing maintenance needs. Weight maintained over a measurement interval is the cumulative number of pounds and can graphically be represented as the area under the growth curve for that interval. For the simple case of linear growth (i.e. ADG is constant over the measurement interval), weight maintained is the product of the number of days in the interval times the average weight ($\overline{WM}$) (midweight) during the interval. This product is D x $\overline{WM}$. The ratio of the number of units of feed utilized just for maintenance per unit of weight maintained can be called the food maintenance (FMR) ratio, and the product of it and the total weight maintained represents total feed just for maintenance. Thus Feed for Maintenance = D x $\overline{WM}$ x FMR.

Substituting into our Feed/Gain formula, we have:

$$\frac{\text{Feed}}{\ } = \frac{D \times \overline{WM} \times FMR}{D \times ADG} + \frac{D \times ADG \times FCGR}{D \times ADG}$$

This representation applies to any interval of measurement for an animal. A further simplification can be attained in representation of $\overline{WM}$, average weight maintained. Average weight maintained in the linear (constant ADG) gain situation is initial weight (WI) at the start of the interval plus one-half of the gain made during the interval. Thus, $\overline{WM} = WI + \frac{1}{2}(D \times ADG)$, and we have the following:

$$\frac{Feed}{Gain} = \frac{D \times [\ WI + \frac{1}{2}(D \times ADG)] \times FMR}{D \times ADG} + \frac{D \times ADG \times FCGR}{D \times ADG}$$

From the above formula, a representation to understand time and maturity constant interval feed efficiency is obtained by algebraic cancellations. Use of the substitution of Gain = D x ADG along with algebraic cancellations yields the representation for the weight constant interval. These results are as follows:

Time or Maturity Constant Interval

$$\frac{Feed}{Gain} = \left(\frac{WI}{ADG} + \frac{D}{2}\right) \times FMR + FCGR$$

and Weight Constant Interval:

$$\frac{Feed}{Gain} = Dx\left(\frac{WI}{Gain} + \frac{1}{2}\right) \times FMR + FCGR$$

Measurement Interval Comparisons

Now that we have the intervals represented by their components, we can examine sources of genetic variation in feed efficiency. Let's start with the only component in the Feed for Gain portion of the utilization. FCGR varies among animals according to composition (lean vs. fat tissue) of gain only.

Due to the necessary biochemical processes required for producing new lean or fat tissues there appears to be little or no opportunity for one animal to produce lean more efficiently than another animal when consideration is given only to the feed just used directly for new growth. Research results have shown almost identical energy (feed) costs per dry unit of protein and fat (Pullar and Webster, 1977). However, lean tissue has a very high proportion of water (around 75%) as compared to a much lower proportion of water in fat tissue (10 to 20%). Thus, per unit weight deposition of lean tissue costs less than fat tissue.

Variation in composition of gain is caused by differences in mature size and maturing rate. Over a maturity constant interval, little or perhaps no variation of FCGR could be expressed between animals. Time and weight constant intervals would both have variation in FCGR due to different compositions of gains of animals.

Variation in FMR would arise from differences in resting metabolism rate, activity, health, etc. between animals. Variation in activity, health, external temperature, etc. are minimized as much as possible by feeding animals in a contemporary environment. However, these differences can be large. Variation in resting metabolism is dependent upon composition of weight to maintain and other sources. Research data from pigs (Dickerson, et al. 1977) and rats (Pullar and Webster, 1977) have shown that energy costs are higher to maintain lean tissue as compared to fat tissue. In a maturity constant interval, we would expect less variation in FMR since composition (maturity) is considered constant.

The other components in the formulas pertain to WI, ADG, D and Gain. In the weight constant interval, WI/Gain + ½ is a constant for all animals since they are on the same weight interval. Thus, differences in growth rate are reflected in variation in the number of days (D) to make the specified gain. In the time constant interval, D/2 is fixed but WI and ADG vary. However, WI and ADG are positively related, i.e. animals with larger WI will tend to have faster ADG. Thus, in the ratio of WI/ADG, much of the variation is "washed out" or removed. In the maturity constant situation, variation resulting from growth rate differences is reduced in the WI/ADG ratio, but days are variable for animals and this is reflected in the measure (D/2).

Of the three measurement intervals, we would expect more variation between animals with the weight constant measure and the least variation with the maturity constant measure. Variation due to growth rate differences (with faster growth rate, more feed is freed up from maintenance and can be used for growth) is not suppressed in the weight constant interval but is suppressed in the time and maturity constant interval . Variation due to composition of growth is suppressed in maturity constant measurement. Variation due to differences in resting metabolism is present in all three measurement intervals. Thus maximum expression of variation is possible in the weight constant interval.

Some Research Results

Data from the U.S. Meat Animal Research Center (USMARC) Germ Plasm Evaluation (GPE) project as reported by Smith, et. al. (1976) are shown in Table 1. Postweaning gain and feed consumption were collected on steers out of Hereford and Angus dams and Hereford (H), Angus (A), Jersey (J), South Devon (SD), Limousin (L), Charolais (C) and Simmental (S) sires. Feed efficiency is presented as megacalories of metabolizable energy per unit of gain over the interval of measurement.

High values are least desirable. Data were adjusted to constant measurement intervals using within breed group regressions to retain the genetic variation between the groups.

The range of breed group mean efficiencies (Table 1) is 20.62 to 22.57 (1.95 units) for the time constant (0-217 days on feed) measurement as compared to 19.49 to 24.54 (5.05 units) for the weight constant (240-470 Kg live weight) measurement. The larger variation in the weight constant interval efficiencies as compared to the time constant interval is expected due to the reasons stated earlier in this discussion.

The breed group differences in the weight constant measurement demonstrate the presence of additive genetic variation for feed efficiency measured in this manner. A large proportion of that variation is explained by variation in growth rate. Faster growing animals have fewer days of maintenance over a weight constant gain interval and thus partition less of their feed intake into maintenance allowing more feed to be used for new tissue synthesis. The correlation between weight constant efficiency and ADG (first 180 days on feed) was 0.82. Days on feed (D in our formula expressed earlier) accounted for 88% of that variation in weight constant efficiency. The weight constant measurement also favors animals which have leaner composition (more favorable FCGR discussed earlier) of gain or are less mature over the interval. This should explain at least part of the large difference between the Limousin crosses (21.23) with their leaner gain during this interval compared to the Jersey crosses (24.54) even though ADG was more similar (1.08 and 1.04). One must recognize, however, that composition of gain and growth rate, during similar ages, are related and confounded in the measurements.

TABLE 1. Breed Group Means for Postweaning Gain and Cumulative Feed Energy Per Unit of Gain (USMARC-GPE)[a]

Breed Group[b]	Postweaning ADG, 180 days Kg/day	Time Constant Efficiency, 0-217 days Mcal/gain, Kg	Weight Constant Efficiency, 240-470 kg Mcal./gain, Kg
HH + AA	1.11	21.07	23.02
HAx	1.12	21.66	22.14
Jx	1.04	22.57	24.54
SDx	1.20	21.35	21.54
Lx	1.08	20.91	21.23
Cx	1.24	20.62	19.49
Sx	1.25	21.37	20.56

[a]Smith, et al. (1976)

[b]HH + AA = average of Hereford and Angus purebreds.

HAx = average of Hereford x Angus and Angus X Hereford
Jx = average of Jersey x Angus and Jersey x Hereford, etc.

Evidence for non-additive genetic variation in feed efficiency has surfaced when measurement is on a weight constant interval. Comparison of HAx to HH + AA in Table 1 shows -2.8% (desirable) heterosis. An additional study of individual heterosis in feed efficiency of growing cattle comes from the Hereford, Angus and Shorthorn crossbreeding project originally at Ft. Robinson and later transferred to USMARC. Olson, et al. (1978) reported the postweaning gain data shown in Table 2. The crossbreds were heavier at the start of the test period, had faster gains and consumed more TDN during the 224-day period. However, when compared on a constant weight basis (227 to 409 Kg.), the crossbreds used less TDN/Kg of gain resulting in the desirable (-.1.6%) heterosis. In both of these studies, heterosis in feed efficiency is partly due to desirable heterosis for gain.

TABLE 2. Postweaning Gain and Feed Conversion Heterosis in Beef Cattle[a]

	Initial Weight, Kg	ADG Kg/day	224 Days TDN, Kg.	TDN/Gain 227-408 Kg.
Crossbreds	216	.91	1108	5.49
Purebreds	210	.88	1082	5.58
Difference	6	.03	26	-.09
% Heterosis	2.6	2.8	2.4	-1.6

[a]Olson et al. (1978) Hereford, Angus and Shorthorn breeds.

Data from a selection project utilizing rats and carried out by Dr. G.E. Dickerson, et al. in Nebraska provide a means for further understanding genetic variation in feed efficiency. Three lines have been maintained for over twenty generations; one line has been selected for increasing lean growth, another line for lean growth efficiency (feed/lean gain) and an unselected control line has been kept. Comparison of the lines for feed utilization began after generation fourteen and these data are presented in Table 3.

TABLE 3. Effect on Lean Gain and Efficiency Selection on Feed Utilization - Constant Weight Interval

	% of Control Line Feed	
	Lean Growth	Lean Efficiency
Days of Maintenance	-14.6	-12.0
Basal Metabolism/Day	-3.4	-4.5
Intake Above Maintenance	+2.6	+2.0
Total	-15.6	-14.4

[a]Wang, et al. (1977) and G.E. Dickerson, Personal communication.

A weight constant interval (for each sex) was used, and the important comparison is the two selected lines vs the control line. For the weight constant interval, the rats in the selection lines averaged 15% less feed intake than the control line rats. At the end of the feeding interval differences in composition were very small between lines. Faster gains, thus less days of maintenance, accounted for a reduction of 12-14% of feed consumed. Reduction in basal or resting metabolism rate accounted for about 4% less feed. An extra need for feed above maintenance (for growth) of about 2% was found also; perhaps there is extra work by the body required for faster growth. Differences between the lines (versus control) would reflect evidence for additive genetic variation. Evidence for genetic variance in resting metabolism independent of composition differences has not been large, and in this study, reduction in feed intake due to faster gain was much more important than reduction in resting metabolism.

Summary

A weight constant interval of measurement will maximize the expression of variation (genetic and non-genetic) in gross feed efficiency of growing animals. Knowledge of whether a weight constant interval is best, whether all breeds (types) should use the same weight interval, etc. for providing opportunities for selection to improve feed efficiency is not presently at hand. The impact on and consideration of total life cycle production efficiency and industry utilization would need to be given paramount importance.

Genetic variation does contribute to variation in feed efficiency on a weight constant interval. Average daily gain is influenced by additive and non-additive genetic variation, and this has a large influence on feed efficiency. Composition of gain influences energy costs of gain and of maintenance, and this is influenced by additive genetic variation. There is also some evidence of additive variation in resting metabolism rate--opportunities for improvement in this component may be the most interesting.

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APPLICATION OF FEED EFFICIENCY KNOWLEDGE

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Determining the relationships of beef cattle performance traits to efficient beef production is a huge task. Evidence needed to reach reliable conclusions is buried in confusion arising from the confounding of age, weight and environmental variations. Few experiment stations have the resources needed to carry out selection experiments capable of demonstrating reliable results and furthermore, while there is an immediate need for information, the experimental approach would require decades.

Selection experiments with small animals have amply demonstrated that selection will produce genetic change. The principles of population genetics also provide a basis for translating short-term observations on cattle performance into selection procedures patterned after those of the smaller animals. But beef cattle are different. They are different in their reproductive rate, the feedstuffs they consume, and the degree of control that can be exercised over the environment in which they are raised. It is in the context of making feed efficiency a part of the entire beef cattle production system that we choose to discuss its applications.

We will begin by reviewing the results of Smith et al. (1976) in which they compared the performance of several cattle breeds for growth rate, feed consumption and feed efficiency, and define a model for the effect of differences in mature size and its impact on differences in feed lot performance. The results of the Smith report are of tremendous importance to the beef industry not only because they characterize several breeds from the vast pool of germplasm available to us, but because they identify the most important element of variation among these resources, mature size.

FEED EFFICIENCY DEFINED

Feed conversion may be calculated as units of feed consumed divided by units of gain produced, or, the calculation can be reversed. Which ratio one chooses is unimportant since if feed intake and gain are measured on standard scales the two ratios differ in sign but not in the magnitude of their relationships to other traits. We prefer, because of habit, to work with feed/gain which we refer to as feed efficiency. Low feed efficiency values are desirable.

Feed efficiency is one of the more important traits in animal production because it equates a major cost item, feed, to amount of meat produced. Measurement

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cross with Hereford X Angus crosses intermediate. The differences become clearer as the test progresses and consumption by each breed appears to accelerate upward. The results for turkeys, figure 4, agree with those for beef cattle. Clearly the upward trend is real and eventual mature size is the dominant factor determining the results.

Feed Efficiency

Differences in performance of beef cattle for feed efficiency appear (figure 5) as intake/gain plotted against day of test. Charolais crosses represented by the lower line, are most efficient throughout and the Jersey crosses are least efficient.

Results from the turkey trials are given in figure 6. Except at early ages this figure reflects the impact of mature size in a manner similar to that for beef cattle. Left-hand portions of the curves could reflect improper correction of feed consumption for mortality, response to initial filling of the digestive tract or other phenomena. The exponential nature of response is obvious and should be expected because F/G must increase to infinity as ADG drops to zero. A transformation to logarithms would partially linearize the relationship of the ratio to its components (Sutherland, 1965). It seems that major differences in performance of the Clay Center steers are expressions of differences in mature size of the breeds. When feedlot performances of individual bulls are compared much of what the records reflect, whether the comparisons are between animals of different breeds or within a single breed, is mature size.

CONSTANT-WEIGHT COMPARISONS

As pointed out by Smith *et al.* (1976), it is easier to understand what is taking place by comparing performance of breeds for growth rate, feed consumption, and feed efficiency at equal weights than of similar age or calendar date. Comparisons of rates are more sensitive than those of cumulative performance.

Growth Rate

Figure 7 compares performance of the three turkey varieties for average daily gain (ADG) when their weights are identical. This is analogous to compare bulls over a test interval of 500 to 900 pounds, for example. Absolute growth rate is small immediately after birth, increases to a maximum and then declines to zero at maturity. This figure shows that average daily gain at any weight is always greater for birds of the largest variety. The relationship of growth rate to weight is constant when comparisons are made at the same percentage of mature size. Thus, turkeys of the Medium variety weighed 28% more than those of the Small variety at the peak of the growth curves and at the point where growth is predicted to cease. Similarly, turkeys of the Large variety weighed 54% more than those of the Small variety and 20% more than those of the Medium variety at similar percentages of mature weight.

of feed consumption on individual or small groups of animals is expensive. Since feed efficiency is highly (75 to 80%) and favorably correlated with growth rate, selection for growth rate achieves a large part of that resulting from direct selection.

BREED DIFFERENCES AND PERFORMANCE FOR FEEDLOT TRAITS

Goodearl (1947) (also Lasley, 1949) sampled three types of turkeys, and compared their growth and development from hatching to market. The experiment was repeated for three years. Within each year, eggs of each type of turkey were incubated at the same time to remove age differences from the comparisons, and common feed and management was provided to reduce non-genetic variation. Thus, a growth interval from hatching to mature size (weight) was observed. This experiment provides a model of animal performance for growth rate, feed consumption, feed efficiency and mature size which will be compared with the results of Smith et al. (1976). The purpose of this comparison between turkeys and cattle is to emphasize the impact that differences in mature size have on performance and the priority that must be given to mature size in the development of beef cattle breeding and improvement programs.

Although seven breeds of cattle were compared in the Smith report, we will consider only three crosses, calves from Angus and Hereford cows sired by Jersey and Charolais bulls and reciprocal crosses between Angus and Hereford cows and bulls. Smith's figures were modified by deleting performance of other crosses. These three cattle crosses were selected because they differ in mature size as do the turkey varieties.

Growth

Figure 1 summarizes postweaning weights for steers plotted against days on feed. Three important observations can be made. First, Charolais were heaviest throughout the test. Second, differences between breeds increased as age increased. Third, growth rate appears to be decreasing as the test progresses. Compare cattle results with those derived from the turkey trials, figure 2. The Large type of turkey was also heaviest throughout, and differences in weight between the three varieties also steadily increased. The Large variety weighed about 21 pounds, the Medium variety about 17 pounds, and the Small variety about 13 pounds at maturity (males and females averaged).

Although there is an intermediate area of approximately linear growth, as the trails progressed growth began to decline. Whether or not the cattle results should be interpreted as representing the third quarter of growth is unclear. The cattle graphs present a pattern similar to that portion of the turkey figure represented by an interval beginning at about 35% and extending to about 80% of mature weight. Clearly difference in mature size is a dominant factor in the growth performance of both beef cattle and turkeys.

Feed Consumption

Figure 3 compares postweaning energy intake at different stages of test. Consumption is greatest for the Charolais cross and least for the Jersey

When similar comparisons were made by age the differences in rate of growth were also constant but of lower magnitude. Turkeys of the Large variety weighed 9% more than those of the Small variety and Medium birds weighed 3% more than those of the Small variety. Thus, differences in growth rate are more apparent when compared for constant-weight intervals than for constant-age intervals. Bull tests should provide comparisons among animals of similar weight if the effects of mature size are to be recognized most clearly.

Feed Consumption

Figure 8 compares performance of turkey varieties for ADC at different weights. As turkeys grow the amount of feed needed for maintenance increases. Thus, ADC increases until maturity is reached.

At any given weight turkeys of the Large variety are both growing at a more rapid rate and consuming more feed than those of the smaller varieties. All other observations can be placed in perspective by this relationship of ultimate mature size to growth rate and rate of feed intake. This is true for both turkeys and beef cattle.

The relationship of feedlot performance to mature size has been observed by several researchers. Leckley (1960) reported a genetic correlation of 0.64 between ADG and mature size; Brinks (1964) observed that weight at all ages is positively correlated with mature size; and Taylor (1973) concluded that differences in feed consumption and in growth rate are proportional to mature size.

GROWTH-CONSUMPTION-EFFICIENCY

The results of the turkey experiment are summarized in Table 5. When ADG decreases to zero, feed consumed is used only for maintenance (growth having ended). Earlier segments of the feed consumption curves can be partitioned into two parts: feed used for growth and feed used for maintenance. Weight to the 0.8th power (Brody, 1945) was used for this purpose. Large turkeys were more efficient in the use of feed available above maintenance averaging 0.62 pounds of feed per pound of gain compared to 0.76 for the Medium and 0.75 for the Small birds. The relationship between Large and Small birds was true at every level of maturity (percent of mature weight). Small birds were less efficient than Medium birds up to 30% of mature size but out-performed them thereafter. The proportion of feed intake utilized for growth declined as maintenance needs increased. Estimates of F/G less than one would seem unreal except that allowance for contents of the digestive tract and high water content of muscle remain to be made.

The Large variety of turkey required a higher percentage of its daily feed intake for maintenance because it was consistently larger throughout the experiment. In spite of this, however, its higher growth rate allowed it to produce more meat per pound of feed consumed. Size appeared to be an advantage once the poults were hatched. But, larger feed requirement for maintenance would be a disadvantage for the Large variety in the breeding flock unless it also had a higher rate of egg production. Mature size obviously is an important consideration but the situation is far more complex than just size itself. Differences in efficiency that aren't explained by mature size apparently exist.

SELECTION EXPERIENCE

Response to direct selection for feed efficiency has not been demonstrated with beef cattle. Bailey et al. (1971) reported results from an experiment in which feed efficiency was a selection objective in two of five lines. After about two generations the results were inconclusive. The authors stated in their summary that "Regressions of gain/TDN on dam birth year in the gain lines were about the same order of magnitude, or somewhat higher, as compared to values for lines in which direct selection was practiced for increased feed efficiency, suggesting that many of the genes which control the expression of growth rate of beef cattle are also responsible for efficiency of feed utilization". That experiment has been terminated.

Feed efficiency is a selection objective in a beef cattle experiment underway at the Kansas Experiment Station. Schalles et al. (1977) summarized five years of progress showing an accumulated selection response of 0.19 pounds less feed per pound of gain. This experiment includes an unselected control population.

Most of the information that is available from which to predict the outcome of selection for F/G is in the form of estimates of genetic and phenotypic values.

HERITABILITIES AND CORRELATION AMONG TRAITS

Heritability of traits can range from zero to 100%; the higher the value the greater the expected response to selection since it measures the proportion of the differences among animals that are transmitted to the offspring. Two traits may tend to vary together or in opposite directions for environmental reasons or for genetic reasons. Phenotypic correlations are estimates of tendencies of traits to vary favorable or antagonistically. Genetic correlations reflect only genetic reasons for such associations. Correlations are useful in evaluating the expected response when selection is practiced for two or more traits. Only approximate values are available. Table 2 summarizes estimates of heritability and correlation for birth weight, weaning weight, ADG and F/G. The heritability of ADC is about 0.45. Its correlation with average daily gain is in the .7 - .8 range and that with F/G is low and antagonistic. Since increased weaning weight is desirable the correlation of ADG with F/G is favorable. However, if lower birth weight is desired selection for improved feed efficiency would be antagonistic.

Figure 9 is believed to describe the impact of selection for F/G on consumption and growth rates. It is based on an analysis of bulls fed at the Farmers Hybrid bull test station. A similar relationship exists when selection for F/G is practiced in pigs (Lasley, 1977). When bulls are ranked based on F/G records, the higher performers (left side of figure) are most apt to be those with the higher performance for ADG. At the same time, there is a tendency to identify bulls with below average rates of feed consumption. Thus, F/G is a convenient index which combines performance for ADG and ADC into a single measure. Cattle will probably respond to selection for F/G just as they do for ADG or yearling weight. Cost of measuring feed consumption and correlated response for large mature size are major roadblocks to the use of F/G as a selection criterion.

EVALUATION PROCEDURES

Gain may be estimated by the within-animal regression procedures described by Mavorgenis et al. (1978) by the difference between two or three weights taken at the beginning and, again, at the end of test, or by the difference between an initial and final weight. Weighing errors and variations in fill are minimized by the within-animal regression procedure and, to a lesser degree, by averaging two or three initial and final weights. Since animal weight may reflect conditions that persist for several days, superiority of within-animal regression is probably greater than indicated by statistical projection. The within-animal approach also reduces any need for overnight fasting prior to weighing.

Standard errors of ADG and ADC measurements, based on our experience using PINPOINTER devices to measure daily feed consumption and two-week intervals between weighings, were estimated to be:

METHOD	ADG	ADC
REGRESSION	0.11	0.35
SINGLE WEIGHTS	0.20	0.62
TWO WEIGHTS	0.15	--
FIVE 2-WEEK INTERVALS	--	0.37

An estimate of individual bull performance for ADG based on a single initial and final weight might be 2.90 pounds per day. In our experience we would expect the true performance of this bull to lie in the range, 2.90±0.20, or between 2.70 and 3.10. If we could test this bull again and again we would expect that two-thirds of the resulting estimates would fall within the range, 2.70 to 3.10. By contrast, we are much more confident of an estimate of individual performance obtained by the regression method because its "confidence interval" is ±0.11.

Feed consumption can be estimated by within-animal regression of cumulative feed on day of test at intervals throughout the test or as total feed consumed. The within-animal regression procedure is most precise.

The results for feed consumption indicate that more reliable estimates would be produced by measuring it during alternate two-week intervals (one-half of the time) than as a single cumulative value. The Iowa Beef Improvement Federation follows this practice in order to double the number of bulls that their PINPOINTER machines can serve.

Increasing the length of test reduces standard errors of all the above procedures. Increasing the frequency of intermediate measures reduces the error when within-animal regression is used.

The results of Mavrogenis et al. (1978) suggest that heritability of feed efficiency is increased when growth rate and feed consumption are estimated by the within-animal regression method. Higher heritability should mean greater response to selection.

REPRODUCTION, FEED EFFICIENCY AND SELECTION OBJECTIVES

The similarity of beef cattle and turkey results can be no accident. Knowledge of breed differences for mature size foretell, to a significant extent, the relationships that exist for feedlot traits. There is also evidence that differences in mature size adversely impact reproductive performance. In another paper Smith et al. (1976b) show that dystocia increased with birth weight and that heavier birth weights are associated with breeds of greater mature size. Gestation length also appeared to be related to mature size. Thus, the present rate of emphasis on growth rate in the beef industry suggests that increased reproductive problems lie ahead. Unfortunately, selection for feed efficiency or for growth rate plus feed efficiency apparently offers no simple solution to this problem.

Reproductive performance is low. Wiltbank et al. (1961), Bellows (1968) and Gee (1978) provide substantial evidence that only 70-73% of the beef cows placed in breeding pastures wean a calf. While crossbreeding can significantly increase effective reproductive performance, the number of available breeds that are compatible for mature size is barely sufficient to permit maximum exploitation of heterosis. Meanwhile, selection for feed efficiency and growth rate is a race toward larger cattle.

RESTRICTED SELECTION

Our bull selection results indicate that individuals having large birth weights are favored both in choosing performance test candidates and herd sire replacements. When gain and feed efficiency are included in the selection index, the correlated response for birth weight is of the magnitude of about six pounds per standard deviation of selection. Dickerson et al. (1974) proposed an index that combine selection for smaller birth weight and heavier yearling weight to reduce the impact of selection for yearling weight on increased birth weight and presumably, associated calving difficulty.

We have calculated similar indices for use for pretest selection and post test selection. Details of the calculations appear in the Appendix. The following pretest selection index is expected to reduce genetic change for birth weight almost to zero.

$$I = 15 - (BW) + 0.5\,(WW)$$

where,

BW = birth weight
WW = weaning weight
$\bar{I} \approx 100$
$s_I \approx 20$

The index for post test performance is

$$I = 215 + 0.3\,(ADG) - 10\,(F/G) - 0.55\,(BW)$$

where,

ADG = average daily gain

F/G = feed per pound of gain

$\underline{BW}$ = birth weight

$\bar{I} \approx 100$

$s_I \approx 10.6$

The low coefficient for ADG, 0.3, indicates that most of the variation among bulls for this trait is needed to offset related variation in birth weight, consequently the final ranking of bulls is largely determined by variation in feed efficiency. Some form of restricted index may provide a partial solution to the problem of conflict between feedlot and reproductive performance goals.

FEED EFFICIENCY - WHAT DOES IT MEASURE?

There may be situations in which the added cost of measuring feed consumption is a worthwhile investment. We have assumed that feed efficiency is an essential part of the breed characterization process and that it provides a wider range of selection options. There are differences of opinion about what feed efficiency measures. The following list is an attempt to enumerate possibilities. Feed Efficiency

1. measures an important input/output relationship.

2. provides a convenient and workable index summarizing joint growth rate and feed consumption performance.

3. characterizes performances of individuals and breeds. Consumption can be measured as accurately as gain. Information on both traits provides more evidence than on either.

4. may reflect difference in

    a. body composition
    b. metabolic rate
    c. biosynthesis
    d. behavior
    e. approaching maturity
    f. work performed

SUMMARY

1. Observations on turkeys and beef cattle demonstrate similar impact of mature size on feedlot performance.

2. Feedlot performance is highly dependent upon mature size--today's goals for growth rate and feed efficiency favor animals of greater mature size.

3. Greater mature size may affect reproductive performance unfavorably.

4. The partition of feed consumed into growth and maintenance components was demonstrated.

5. The results presented suggest that differences in efficiency for true growth may exist -- at least among turkeys.

6. Cattle probably respond to selection for feed efficiency just as they do for growth. The cost of evaluating feed consumption and the impact of selection for F/G upon mature size would be major roadblocks to this practice.

7. Improved procedures for evaluating feedlot performance, such as the within-animal regression technique of Mavrogenis and coworkers, may increase effective heritability of F/G.

8. Some form of restricted index may provide a partial solution to antagonism between feedlot performance and reproductive performance.

CONCLUSION

Genetic improvement of beef cattle by selection requires a long-term commitment so that selection objectives must be focused on future needs. It must be a balanced effort reflecting both reproductive and growth phases of beef production. Feed efficiency will be a worthwhile criterion for selection only if it can be made to contribute usefully in the development of future germplasm. Its utility for this purpose remains an important issue.

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TABLE 5

GROWTH - CONSUMPTION - EFFICIENCY

	TURKEY VARIETY		
	LARGE	MEDIUM	SMALL
WEIGHT AT MATURITY (lbs.)	21	17	13
ADG (lbs./day)	.084	.071	.056
FEED FOR GROWTH	10%	13%	12%
FEED FOR MAINTENANCE DURING GROWTH	90%	87%	88%
MEAT PRODUCED/POUND OF FEED	0.19	0.16	0.18
FEED REQUIRED FOR MATURE MAINTENANCE	.88	.70	.57
(DAYS) (WEIGHT) 0.8/FEED	22	22	21

Figure 1

POSTWEANING GROWTH CURVE
(USMARC CROSSBREDS)

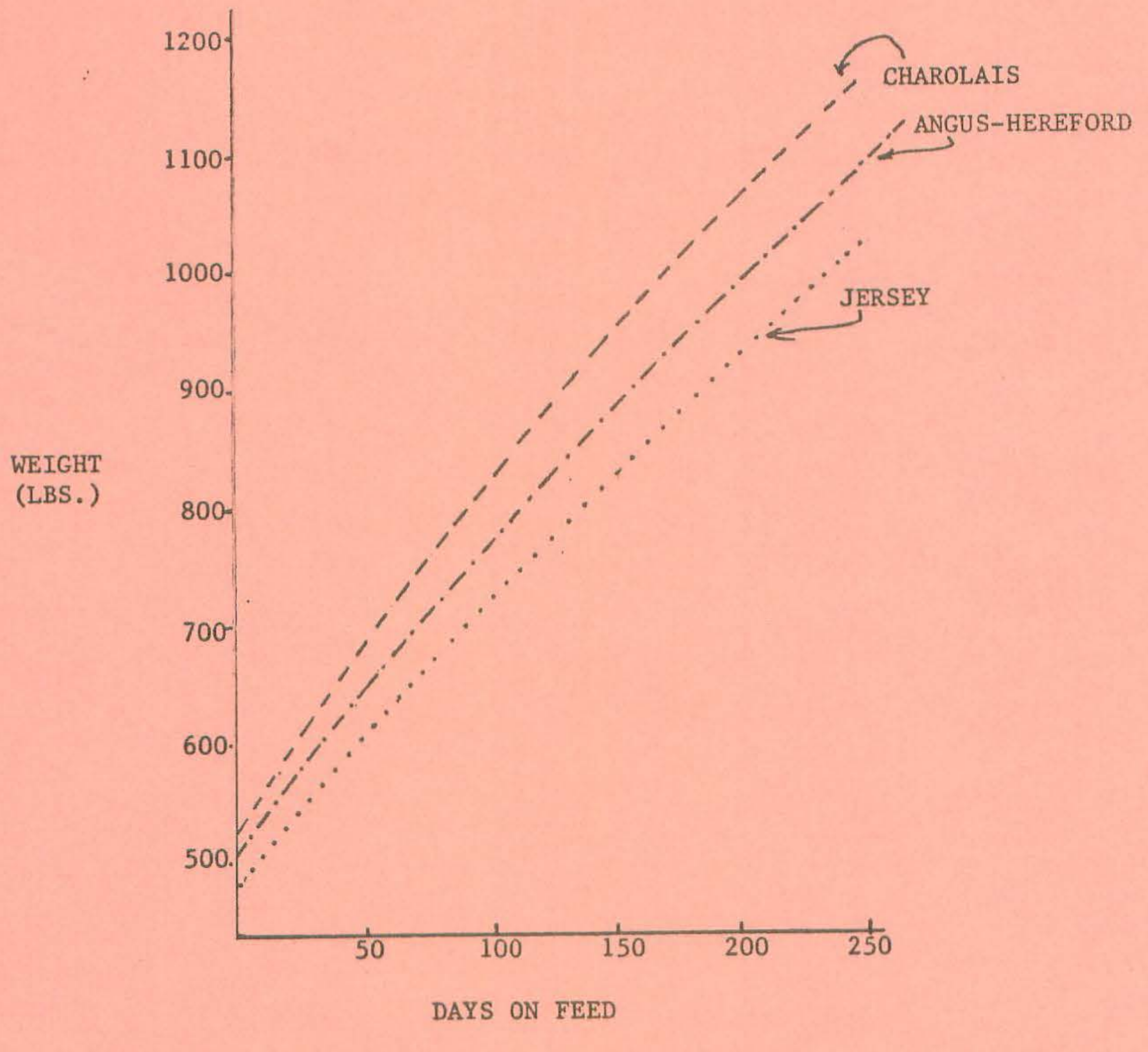

Figure 2

CUMULATIVE GROWTH CURVE
(TURKEYS)

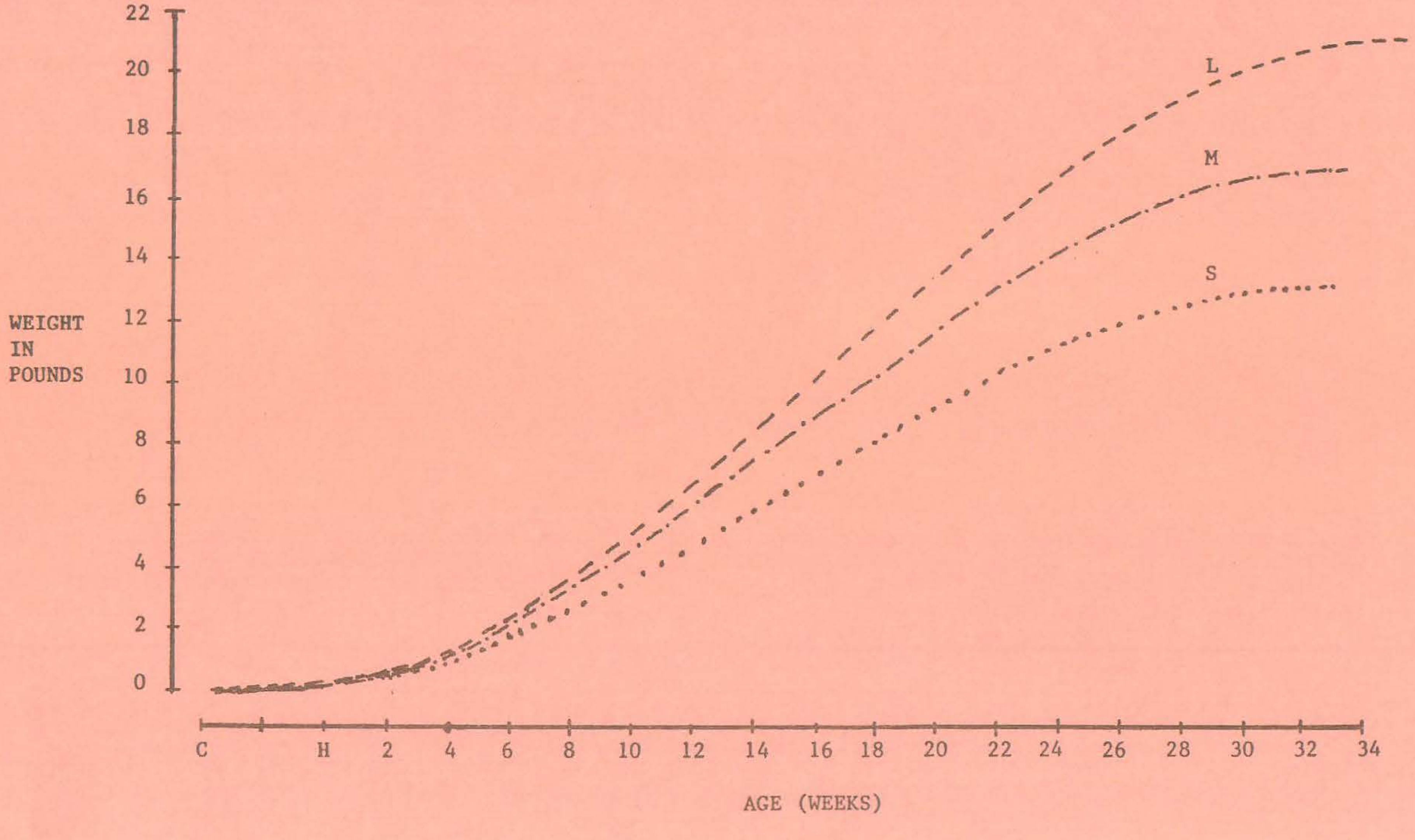

Figure 3

CUMULATIVE FEED CONSUMPTION VERSUS
DAY OF AGE (USMARC CROSSBREDS)

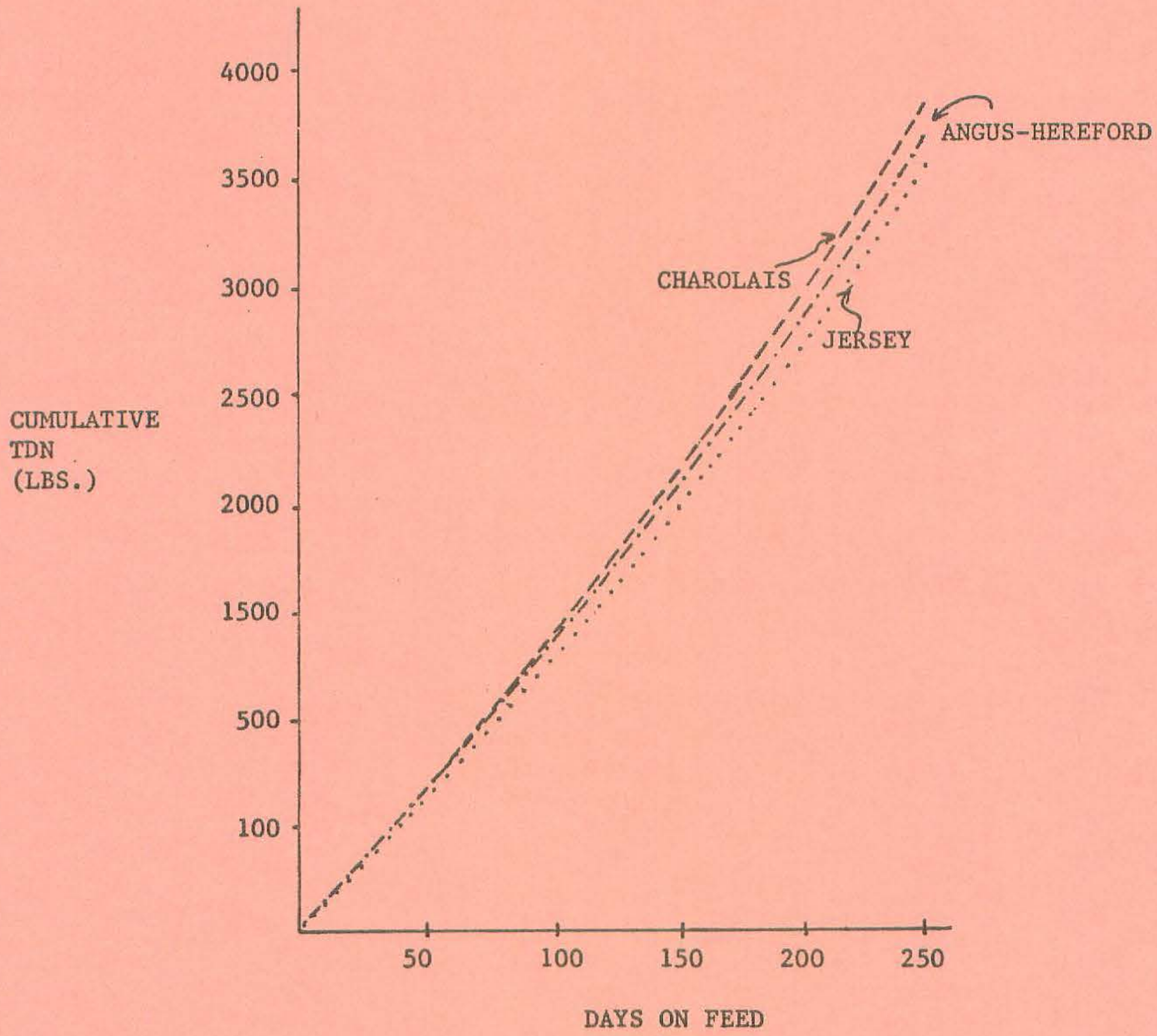

Figure 4

AGE-CONSTANT CUMULATIVE FEED
CONSUMPTION (TURKEYS)

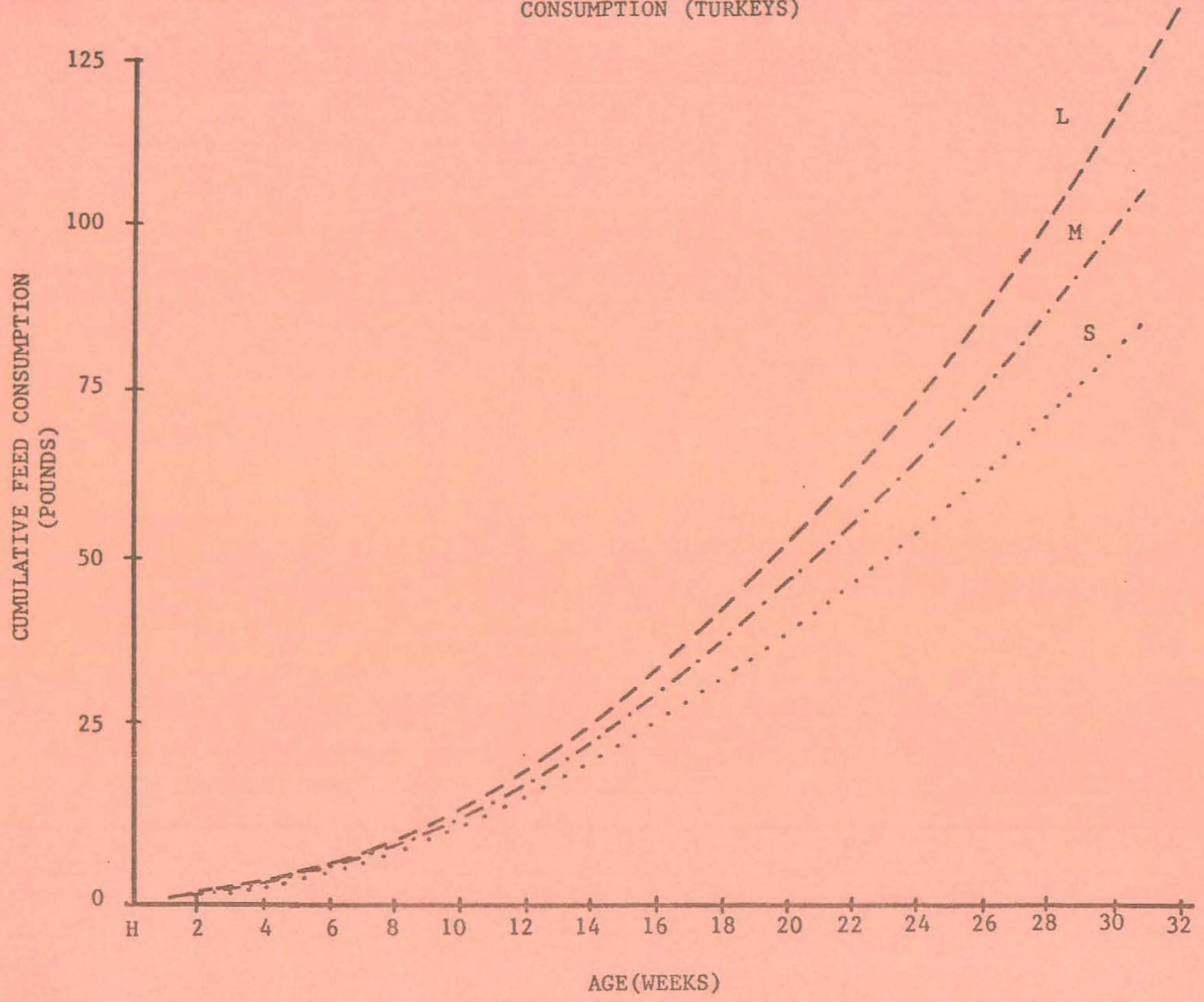

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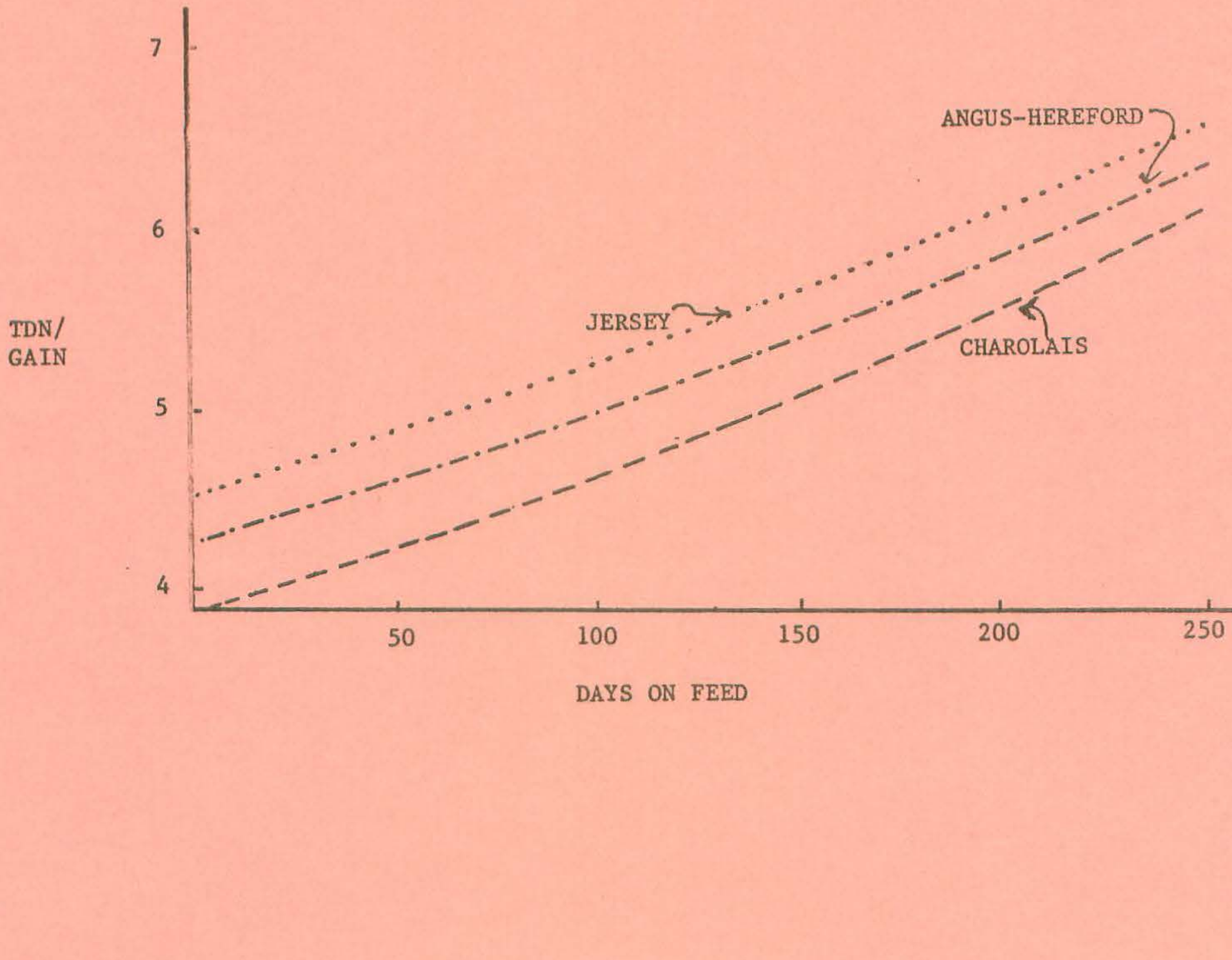
Figure 5

FEED EFFICIENCY OVER AGE-CONSTANT INTERVAL
(USMARC CROSSBREDS)



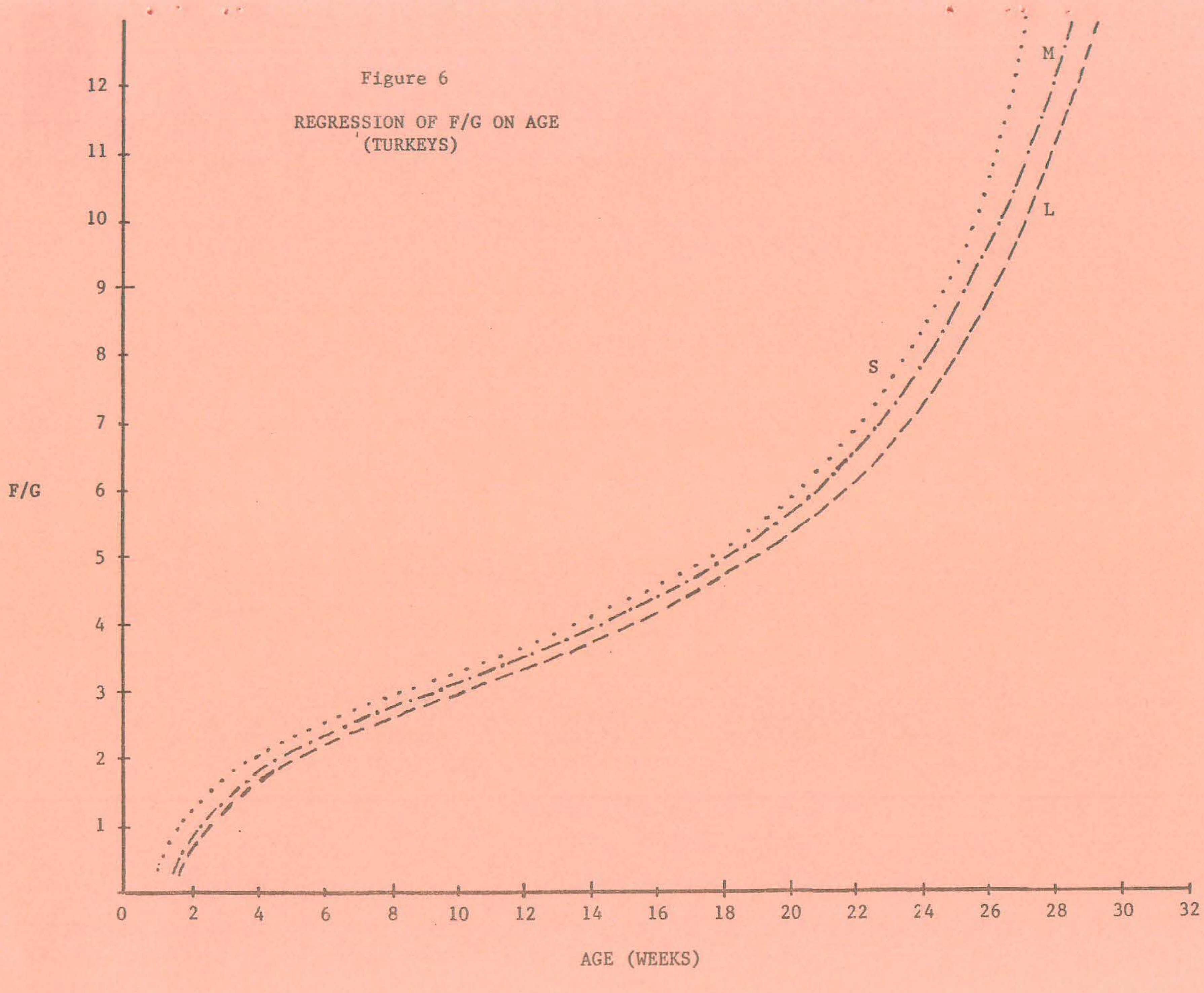


Figure 6

REGRESSION OF F/G ON AGE
(TURKEYS)

Figure 7

REGRESSION OF ADG ON WEIGHT
(TURKEYS)

	BREED		
	LARGE(L)	MEDIUM(M)	SMALL(S)
GROWTH RATE PEAKS AT	10.09	8.36	6.53 POUNDS
GROWTH STOPS AT	20.56	17.10	13.34 POUNDS

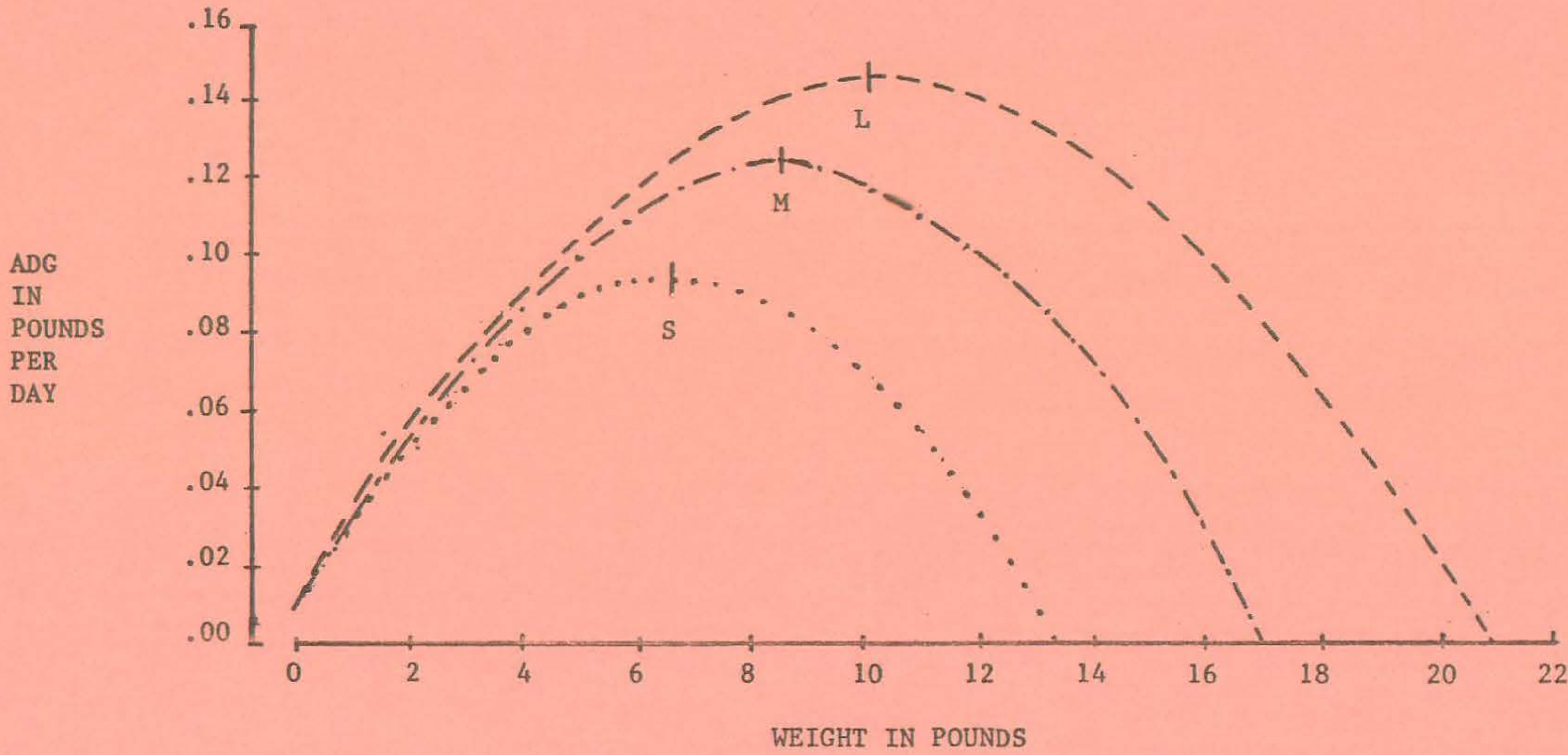


Figure 8

REGRESSION OF DAILY FEED
CONSUMPTION ON WEIGHT

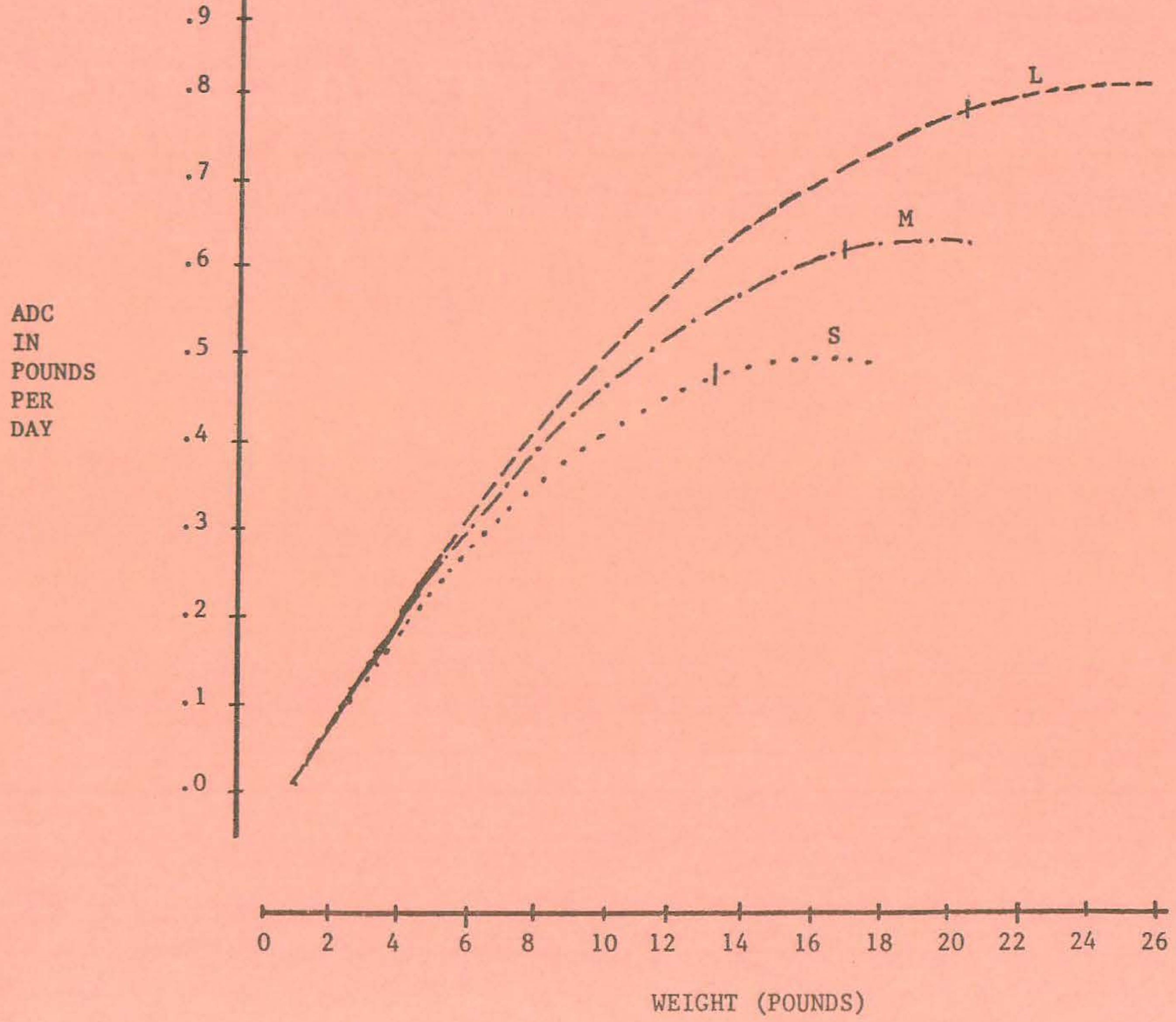
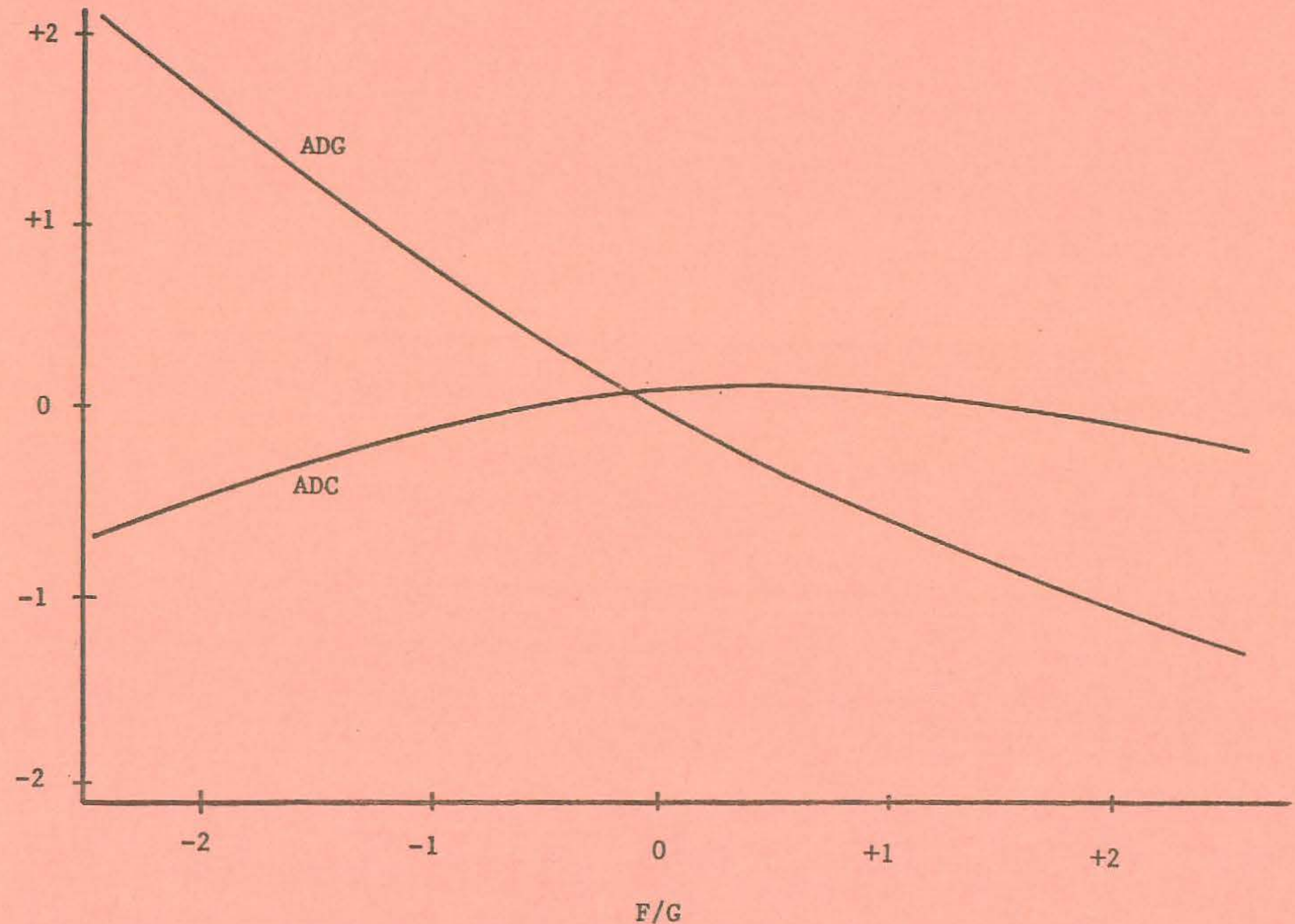


Figure 9

RELATIONSHIP OF ADG AND ADC
TO F/G (BULLS)



Partially Restricted Indices

Parameters obtained from Magnum test results and the technical literature were used to derive indices of pretest and post-test bull selection. Parameters are summarized in Table 1 and Table 2.

Indices were derived using basic procedures of Hazel(1943) by varying economic values iteratively. Indices for pretest selection are tabulated in Table 3 and those for post-test selection appear in Table 4.

TABLE 1

CATTLE PHENOTYPIC AND GENETIC PARAMETER ESTIMATES[a]

	BIRTH WEIGHT	WEANING WEIGHT	ADG	F/G
BIRTH WEIGHT	35.64 81	67.91	.99	-1.86
WEANING WEIGHT	135.45	517.72 1849	1.817	-7.098
ADG	1.395		.0875 .25	-.1616
F/G	-4.14	-19.78	.345	.6083 1.3225

[a] DIAGONAL: GENETIC (UPPER) AND PHENOTYPIC LOWER VARIANCE COMPONENTS
RIGHT OF DIAGONAL: GENETIC COVARIANCE COMPONENTS
LEFT OF DIAGONAL: PHENOTYPIC COVARIANCE COMPONENTS

TABLE 2

ESTIMATES OF HERITABILITY AND GENETIC AND PHENOTYPIC CORRELATIONS[a]

	BIRTH WEIGHT	WEANING WEIGHT	ADG	F/G
BIRTH WEIGHT	.44	.50	.56	-.40
WEANING WEIGHT	.35	.28	.27	-.40
ADG	.31	.20	.35	-.70
F/G	-.40	-.40	-.60	.46

[a] HERITABILITIES ARE ON THE DIAGONAL, GENETIC CORRELATIONS TO THE RIGHT AND PHENOTYPIC CORRELATIONS TO THE LEFT OF THE DIAGONAL.

TABLE 3

WEANING WEIGHT SELECTION INDICES
INCLUDING BIRTH WEIGHT AND WEANING WEIGHT

I NO.	ECONOMIC VALUE[a] BW	WW	COEFFICIENTS BW	WW	G BW	WW	h_I^2	NET VALUE($)
1	-1.00	.30	-1.00	.23	-3.58	8.94	.27	6.26
2	-1.00	.40	-1.00	.36	-1.53	16.14	.24	7.99
3	-1.00	.45	-1.00	.44	- .63	18.38	.24	8.90
4	-1.00	.50	-1.00	.54	.11	19.91	.24	9.84
5	-1.00	.60	-1.00	.81	1.19	21.57	.25	11.75

[a] ECONOMIC VALUE PER POUND CHANGE

TABLE 4

BULL PERFORMANCE TEST SELECTION INDICES
INCLUDING ADG, F/G AND BIRTH WEIGHT[a]

	ECONOMIC VALUE[b]			COEFFICIENTS			E△G			hI^2	NET VALUE($)
	ADG	F/G	BW	ADG	F/G	BW	ADG	F/G	BW		
1	.0406	-.0800	0.0	-1.88	-1.00	.75	-.005	-.547	0.0	.34	4.36
2	.0406	-.0800	-.0040	.08	-1.00	-.04	.178	-.750	.790	.46	6.72
3	.0406	-.0800	-.0050	.03	-1.00	-.05	.161	-.726	.229	.46	6.23
4	.0406	-.0800	-.0060	.03	-1.00	-.06	.142	-.696	-.336	.46	6.15
5	.0406	-.0800	-.0090	-.19	-1.00	-.09	.082	-.576	-1.919	.46	4.96

[a] THE FIRST INDEX IS CALCULATED TO FULLY RESTRICT △G IN BIRTH WEIGHT.

[b] ECONOMIC VALUES: ADG $.0406/.01 lb.
F/G .0800/.01 lb.
BIRTHWEIGHT EV/POUND

WHY USE LINEAR MEASUREMENTS

by

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It is my pleasure to have the opportunity of beginning the discussion on the use of linear measurements in beef cattle performance testing programs. Actually, I prefer to call these measures skeletal size measurements because what we are doing is measuring skeletal size.

The beef cattle industry has had an acute interest in using linear measurements to measure skeletal size for perhaps the past ten years. A great deal of use and misuse has been made by the industry in the use of such measurements. The reason the Beef Improvement Federation is interested in this subject at this time is because there is a felt need to put some guidelines together relative to the use of skeletal size measures. It is a foregone conclusion that the industry is going to use various procedures in measuring and reporting skeletal size. Therefore, it would be fortunate if the industry can become unified, perhaps through the action of BIF.

Some states, such as Missouri, have made linear measurements an essential part of their state beef cattle performance testing program. Other states have used measurements of skeletal size particularly in central bull test stations. As an example, we in Virginia have used and reported hip height on test station bulls. In the earlier years, we simply reported off test hip height; in later years, we have reported hip height at 365 days.

BIF worked on standardization of frame scoring back six years ago in 1973 and in fact, devoted a major portion of one of the annual conventions to this subject. No conclusion, however, was reached and nothing was written into the guidelines. Over time, much effort has been expended by PRI, BIF, and other organizations on conformation scoring. All to no avail.

The Beef Improvement Federation appointed an ad hoc committee two years ago to study and make recommendations on the use of linear skeletal size measures but the suggestions of that committee were not immediately accepted by the BIF board due to a perceived lack of scientific basis. The BIF Live Animal Evaluation Committee, however, took the recommendations of this ad hoc committee, refined them, and presented them to the board as a committee report in 1978. This report was accepted in the fall of 1978 in the BIF board of directors meeting. In addition to procedures for measuring and reporting skeletal size, the following statement was an integral part of the report which was accepted by the BIF board:

> "Linear measurements are objective. They serve as supplemental information for comprehensive performance testing. How much emphasis a breeder should place on linear measurement information should depend on his goals relative to shape and growth patterns; the extent to which certain shape relationships may be important to him and any advantage they give the breeder in marketing cattle. In no way should linear measurements be interpreted as a replacement for weight at a given age. Instead, measurements should be

used with growth information to preduct the accuracy of selection. No one frame size will be best for all feed resources, breeding systems, and cost of feed. Reproductive efficiency and market weight will determine the optimum frame size range within a given set of feed resources, breeding systems, and cost of production."

Scientific Background

I will not attempt to do a complete literature review or give a complete background on the scientific evidence for the use of linear measures. The work reported in this area goes back to 1930 or before, showing that many workers were interested in measures of skeletal size and other linear measurements nearly 50 years ago. Many of these workers were interested in predicting performance by the use of linear measurements. The following table gives heritability estimates for skeletal size measures reported in the literature.

HERITABILITY ESTIMATES
SKELETAL SIZE MEASURES

Workers	Breed	Kind	Wither	Hip
Gowen (1933)	J	Cows	.60	-
Schutte (1935)	X	--	.76	-
Touchberry (1951)	Hol	Cows	.73	-
Dawson (1955)	Ms	Year	.66	-
Brown (1958)	A	Calves	.38	-
Brown (1958)	H	Calves	.29	-
Johnson (1958)	Hol	Cows	.76	-
Brown & Franks (1964)	A,H	Cows	.41	.69

C. J. Brown and others at the University of Arkansas probably have done as much work in the area of skeletal size measures as any group in the country, and have shown that skeletal size measures are useful in describing animals in a more complete way than weight alone can do. The following table, reported by Brown, 1956, shows the percent of mature weight and skeletal size attained at 12 months of age.

PERCENT OF MATURE WEIGHT & SKELETAL SIZE
AT 12 MONTHS

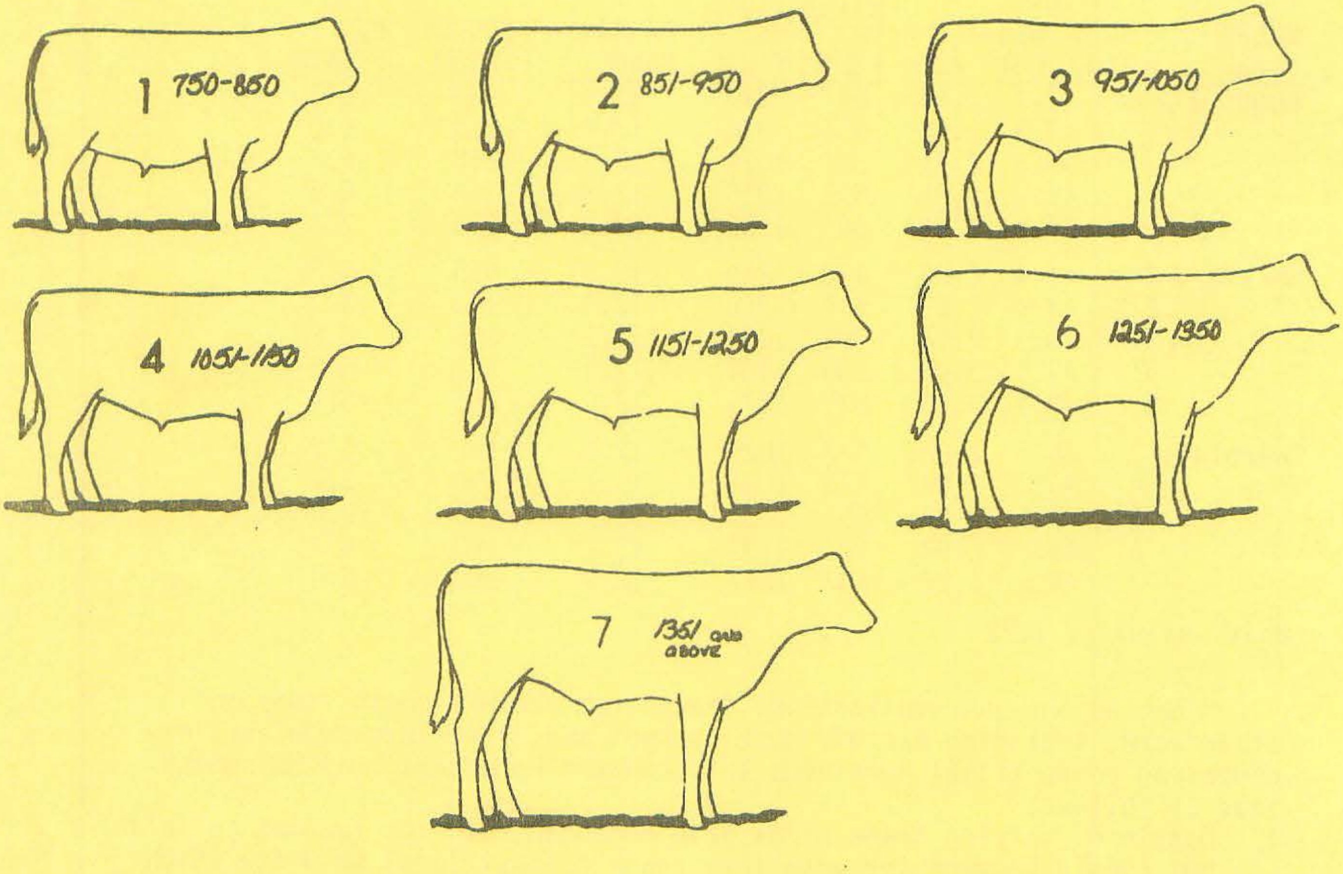
	Hereford	Angus
% Mature Weight	46	51
% Mature Skeletal Size	71-86	80-89

Brown (1956)

There are numerous research studies that have reported positive and reasonably high correlations between measures of skeletal size and performance traits, such as, weaning weight, postweaning average daily gain, final weight, adjusted 365 day weight, birth weight, and mature size. Most simple correlations between skeletal size and these have ranged between .4 and .7.

W. T. Butts, Jr. and others at the University of Tennessee have done considerable work and have shown that frame size is a very logical way to assign feeder animals to appropriate outcome groups. This work has shown that frame size is far more important than fatness or thickness in assigning feeder grades to cattle.

The efficiency and profit differences of Angus, Charolais and Hereford cattle varying in size and growth research done at the University of Wisconsin by Brungardt and others and reported in 1972, has perhaps shed as much light on this subject as any piece of research work done to date. In this particular research involving three groups of cattle - one Hereford, one Angus, and one Charolais cross - cattle were segregated into seven frame types. The Angus and Hereford cattle ranged from frame score 1 to 5, while the Charolais cattle ranged from 3 to 7. The following drawings give the seven body types and the weight range for each expected at a grade of low to average choice.



To put this in a different terminology the following shows the weight at choice for various frame sizes, steers.

WEIGHT AT CHOICE FOR VARIOUS FRAME SIZES
(STEERS)

Frame	Weight Range
1	750-850
2	850-950
3	950-1050
4	1050-1150
5	1150-1250
6	1250-1350
7	1350-Up

The following table shows the summary of growth, weight and efficiency for each frame size for each breed. You will note that there is a distinct difference in height at the withers for the different frame sizes within breeds. You will note also that average daily gain follows frame size. In each breed the larger framed cattle gained faster on feed. The final weight, of course, is heavier in each breed for the larger framed cattle. When fed to a carcass composition of 30% fat, carcass grade was almost identical for each frame size within each breed and for the various breeds. In terms of feed efficiency, the feed per pound of gain for each frame size within breed was almost identical and the differences across breeds were practically identical also. These workers indicated that the Angus cattle were fed a little longer than they should have been or these feed efficiency differences would have been even closer.

SUMMARY OF GROWTH, WEIGHT AND EFFICIENCY

BREED SIZE	FINAL WITHER HEIGHT	ADG	WEIGHT(lbs) ON FEED	WEIGHT(lbs) FINAL	CARCASS GRADE	FEEDLOT PERIOD	FEED PER # GAIN
Angus 1	42.1	2.68	477	877	13.1	153	6.1
2	43.8	2.85	552	984	13.4	153	6.3
3	45.5	2.91	584	1024	13.1	153	6.4
4	45.9	2.86	602	1035	12.8	153	6.5
5	47.1	2.88	669	1106	12.8	153	7.1
Hereford 1	42.4	2.65	478	889	12.3	155	5.8
2	43.4	2.83	519	958	12.3	155	5.7
3	45.3	2.98	593	1055	12.3	155	6.2
4	47.0	3.03	630	1107	12.1	155	6.1
5	48.7	3.23	675	1175	12.8	155	6.4
Charolais 3	45.5	2.92	477	1029	12.2	190	5.8
4	46.8	3.04	520	1093	12.7	190	5.9
5	47.9	3.09	551	1133	12.7	190	6.0
6	49.2	2.99	573	1137	12.2	190	6.1
7	49.5	3.25	597	1211	12.9	190	6.0

Univ. of Wisc. 1972

Conclusions and implications drawn from the Wisconsin study and other work, including a study done by Knox and co-workers much earlier comparing conventional Herefords and comprest Herefords, may be summarized as follows:

1. Cattle of varying frame sizes have economic value as feedlot animals but should be marketed when they reach compositional maturity (high-Good to mid-Choice quality grade and cutability 3 or better) rather than on weight or age.
2. Larger frame heifers or steers gain faster than smaller framed ones on the average.
3. Larger framed cattle must be fed for a longer period than smaller framed cattle to hit the correct end point.
4. Cattle of varying frame sizes (including various breeds) will grade choice if fed to the same fatness end point.
5. If fed to a constant age or weight, large framed cattle are more efficient in feed conversion.

6. If fed to the same fatness end point or compositional maturity, larger framed cattle and smaller framed cattle are about equal in feed efficiency with small frame cattle having a slight edge.
7. Medium to larger framed cattle may be generally slightly more efficient than smaller framed ones in terms of total production efficienty, including investment, land, labor, and facilities.
8. Heifers of all frame sizes are less efficient than steers in feed conversion when fed to a fat constant end point and must be marketed at about 200 pounds less or 80% of the weight of comparable steers.
9. Frame size in feeder cattle is the key to putting like outcome groups together for feeding. Sorting or grading feeder cattle of like ages should be done largely on the basis of frame size.
10. Frame size is the major factor in the determination of finished weight at fat constant end point (compositional maturity).

A statistical technique called principle components analysis has been used to some extent by researchers, particularly James Brown, C. J. Brown, and Butts and the Texas group led by Carpenter to quantify size and shape of cattle on which several measurements including weight and skeletal size have been taken. The first principle component is descriptive of overall size, of which weight is always a significant portion. Skeletal size and fatness also have a significant contribution to overall size. In most analyses reported, the percent of total variance in the system accounted for by principle component one (size) will be considerably larger than for principle components which characterize shape and will generally account for 65-75% of the total variance. Principle components analysis do show that size is more than weight alone, although weight is the largest contributor.

Reasons for Use of Linear Measures

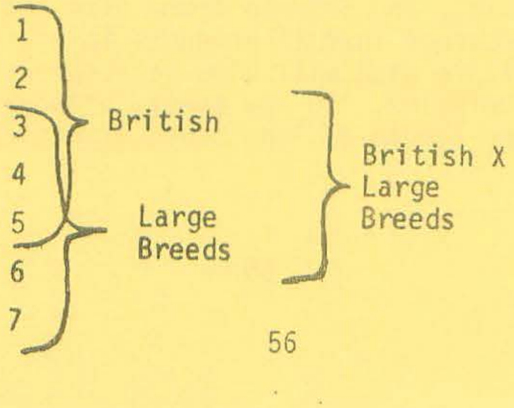
There are a number of reasons why linear measures could and should be used. These are as follows:

1. Description of the package or description of the total animal. There is apparently a definite and strong relationship between weight, skeletal size, and fatness. In fact, if we know two of these parameters, we can fairly accurately derive the third. In determining what an animal is, with regard to size, it is essential that we have an accurate weight, accurate measure of fatness, and an accurate measure of skeletal size. If these three elements of information are given on an animal in question, we can well visualize what this animal is without actually visually appraising the animal.
2. Provides basis for selection. As mentioned earlier, skeletal size is definitely heritable at somewhere near the same proportions as postweaning average daily gain and final feedlot weight. Thus, we know that we can successfully select for or against frame size. We also know that there are positive correlations between frame size and performance traits, and between frame size and mature size. We are justifiably concerned that if breeders select for larger frame size that larger mature size will also be attained because of the strong genetic correlation. In any event, breeders can change skeletal size or the length of long bones at a particular age through selection.

3. Correlates with the commercial industry. This is an extremely important point, particularly since the major criteria for grading feeder cattle in the proposed USDA Feeder Cattle Grades is frame size. Considerable work has gone into formulating the proposed USDA grades with the thought that 85% of the differences in categorizing feeder cattle is due to differences in frame size. USDA is suggesting three frame sizes. The first is large frame which will characterize finished steers with ½ inch of outside fat that will weigh 1200 pounds or more and heifers 1000 pounds or more. Medium frame describes slaughter cattle with ½ inch of fat, steers which would weigh 1000-1200 pounds and heifers 850-1000 pounds. Small frame category for slaughter cattle with ½ inch of fat, steers weighing less than 1000 pounds and heifers weighing less than 850 pounds.
4. Sales appeal. Breeders will use measures of skeletal size and will select for larger or smaller type cattle depending on what the market for their product is paying the most for. To date we have seen breeders select for height sometimes at the expense of growth rate and production because height will sell. Right or wrong, this is a fact of life. Many breeders will want to take the easy way. They will select tall cattle because they say tall cattle gain faster anyway. In other words, breeders like to look for indications of something that is really of more value. In the hog industry, we have seen breeders select for big eared pigs or big tailed pigs because it indicated growth rate. Again skeletal size measures should be used as a descriptive piece of information to go along with conventional performance data.
5. Provides a short cut to the real use of performance selection. Breeders who have found that they have totally unsaleable seedstock animals because of extremely small frame size in this day and age, have selected extremely large frame seedstock to improve their herds in frame size and make their cattle saleable. They could have gotten to the same place by using selection for growth but it might have taken them much longer to do so. In this sense, linear measurements have been used in an advantageous way. We have seen performance levels increase more rapidly since we have generally been selecting for larger framed animals within a breed. I think this is logical. At the same time, we are not saying that breeders should in general use measures of frame size out of context in a selection program. Again, they should be a part of the total performance records package on an animal.

The industry has been, for a considerable length of time, using frame size in sorting feeder cattle into like outcome groups. We have used frame size and breed in an educational way to show cattle feeders what weight they should expect cattle of the British breeds or the large breeds or the crosses between the two to attain at slaughter finish using the following chart.

FRAME SIZE & BREED



What to Measure

It appears that the industry is converging on height as the linear measurement to use for describing skeletal size. Much of the research reported and much of the practice to date has been with wither height. More recently, hip height has become the measurement that appears to be most easily useable. In fact, the BIF Live Animal Evaluation Committee is recommending for the BIF Guidelines that hip height be the recommended height measure to use. This committee is recommending that height be measured when weaning weight and yearling weight is taken. There are obviously a number of ways to measure hip height, but most cattle will be measured in the chute, either with a measuring stick or looking across the animal to a graduated board on the off side of a single animal scale, which in many instances will be the most practical manner of measuring hip height.

What and How to Report

It is fortunate that BIF is in the throes of putting recommendations in the BIF Guidelines for reporting skeletal size measures. The Live Animal Evaluation Committee is suggesting a procedure for adjusting height to 205 days and 365 days. The data for making these adjustments is supplied by the University of Missouri.

Most users of skeletal size measurements have found it useful to designate frame scores based on the Missouri system which is really based on the Wisconsin research. The following tables give the hip height chart in inches for bulls and heifers and corresponding frame sizes that the BIF Live Animal Evaluation Committee is recommending.

BULLS - HIP HEIGHT CHART IN INCHES

MONTHS OF AGE	FRAME SCORES 1	2	3	4	5	6	7
5	34	36	38	40	42	44	46
6	35	37	39	41	43	45	47
7	36	38	40	42	44	46	48
8	37	39	41	43	45	47	49
9	38	40	42	44	46	48	50
10	39	41	43	45	47	49	51
11	40	42	44	46	48	50	52
12	41	43	45	47	49	51	53
13	41.75	43.75	45.75	47.75	49.75	51.75	53.75
14	42.5	44.5	46.5	48.5	50.5	52.5	54.5
15	43	45	47	49	51	53	55
16	43.5	45.5	47.5	49.5	51.5	53.5	55.5
17	44	46	48	50	52	54	56
18	44.5	46.5	48.5	50.5	52.5	54.5	56.5

HEIFERS - HIP HEIGHT CHART· IN INCHES

MONTHS OF AGE	FRAME SCORES 1	2	3	4	5	6	7
5	33.75	35.75	37.75	39.75	41.75	43.75	45.75
6	34.5	36.5	38.5	40.5	42.5	44.5	46.5
7	35.25	37.25	39.25	41.25	43.25	45.25	47.25
8	36	38	40	42	44	46	48
9	36.75	38.75	40.75	42.75	44.75	46.75	48.75
10	37.5	39.5	41.5	43.5	45.5	47.5	49.5
11	38.25	40.25	42.25	44.25	46.25	48.25	50.25
12	39	41	43	45	47	49	51
13	39.75	41.75	43.75	45.75	47.75	49.75	51.75
14	40.25	42.25	44.25	46.25	48.25	50.25	52.25
15	40.75	42.75	44.75	46.75	48.75	50.75	52.75
16	41.25	43.25	45.25	47.25	49.25	51.25	53.25
17	41.75	43.75	45.75	47.75	49.75	51.75	53.75
18	42.25	44.25	46.25	48.25	50.25	52.25	54.25

As far as reporting hip heights and frame sizes, there are a number of ways in which this can be done but, in my opinion, this information should always accompany full performance test data as to growth rate. The following examples are two bulls which were tested in a Virginia test station and sold during the past few months.

LOT 12 — BELLEVUE A S· COLOSSAL 7849 - 9176332

ANGUS

Calved: 12/06/77 **Tattoo:** 7849

Silbersiepen Colossal E 18
- Ankonian Colossal 61
  - Camilla Chance 37 T
  - Inez G
- K Seven Oaks B
  - M. C. Balinesian
  - K 7 Oaks E E

Bellevue Queen 7616 (First calf tested)
- Schearbrook Emulous J91
  - Emulous Pride 135
  - FL Envy Not 4256
- Bellevue Queen 8
  - Plum Grove Elevate 519
  - Bellevue Queen 5

PERFORMANCE RECORD C

	WEIGHT	RATIO	
Wn. Mgt.	Creep		
Adj. 205	583	101	40
Test ADG	3.18	108	13
Off Test	1140		
Adj. 365	1126	110	13
Wt/DA	2.91		
Yr Hip Ht	46		
Frame Sc.	3		
Musc. Sc.	4		
Fat Th.	.5		

Consigned by: Floyd E. Dominy, Bellevue Farm, Boyce, Va.

LOT 26 — GLENOWEN FRITCHIE 2 - 9174427

ANGUS

Calved: 11/8/77 **Tattoo:** 167

Glenowen Fritch
- Fritch of Wye
  - Conan of Wye
  - Fabiola of Wye
- Glenowen Erica 40
  - Bellemonte MW 628
  - Glenowen Erica 19

Glenowen Erica 37 4-529-107
- Bellemonte MW 628
  - Marvin of Wye
  - Bellmonte HM Susan 132
- Glenowen Erica 22
  - Glenowen Bandolier 20
  - Glenowen Erica 14

PERFORMANCE RECORD C

	WEIGHT	RATIO	
Wn. Mgt.	Creep		
Adj. 205	588	119	40
Test ADG	3.71	126	94
Off Test	1290		
Adj. 365	1130	110	
Wt/DA	3.07		
Yr Hip Ht	49		
Frame Sc.	5		
Musc. Sc.	3		
Fat Th.	.4		

Consigned by: Owen Thomas & Sons, Glenowen, Round Hill, Va.

In my estimation, it would not be wise in a set of herd records, either weaning or yearling, to report adjusted hip height in terms of ratio. This would be suggestive to the breeder that large hip height is superior to smaller hip height which may not be the case.

Hip heights can be useful, but again they must be used as a descriptive measure and not as a comparative one.

Future Implications

There is no question but that additional research needs to be done on skeletal size measurements and their uses. Additional research needs to be done, in my estimation, on a bull testing procedure which would tie together weight, gain, skeletal size and fatness. I have thought for a number of years that a bull testing scheme which would test bulls not to an age or time constant, but to a fatness constant would be highly desirable. Such a system needs to be researched. My suggestions for such a system would be as follows:

1. Wean bulls in contemporary groups at 7 months.
2. Put bulls directly on postweaning gain test.
3. Weigh, measure fat and skeletal size every 28 days.
4. Take each bull off test at a constant fatness not at a constant number of days on test. Bulls perhaps should come off test when they have say .35 inches of backfat over the 12th rib which would be equal to a steer with .5 inches.
5. Compute age on each bull to the fatness constant end point. Compute test average daily gain and report. Compute lifetime average daily gain and report. Report hip height and frame size.

In conclusion, let me just suggest that what we are talking about in linear measures or measures of skeletal size is another tool to refine performance records on beef cattle. We should keep skeletal size measurements in the proper context and realize that what we really need across the industry and particularly in registered seedstock herds are breeding programs that are scientifically based. We have far too few breeders engaged in a performance selection breeding program. We should never recommend that a breeder sacrifice performance for height. On target breeding programs should select for growth rate bounded by reproductive efficiency.

HOW WE USE LINEAR MEASUREMENTS

Burke Healey

"No fact is so simple that it is not harder to believe than to doubt at the first presentation."
- LUCRETIUS

I thought the admonishment of Lucretius some 2,000 years ago was particularly appropriate at the start of my presentation. As you're aware, I've been asked to discuss "How We Use Linear Measurements". I realize only too well that there are many skeptics in the audience who presently doubt that linear measurements have any value whatsoever. I hope that perhaps I can convince some of the skeptics of the merit of this technique as a valid tool in selecting and fixing performance in a herd. For those that aren't convinced perhaps I can at least plant a wee seed of curiosity.

There is no doubt in my mind that we in the beef industry are at a new dawn in evaluating the performance of our cattle. New techniques to help us improve the performance and profitability of our herds are literally exploding around us like fireworks. No longer will the scales be the only tool available to us. New and greater emphasis will also be placed on measuring such things as birth weights, rib fat, and most certainly frame size.

In this last decade our industry has seen a flood of good scientific research in these and other areas. Research has poured in from such distant shores as Scotland, England, Canada, Australia, Rhodesia, and South Africa as well as from our own universities and other government research facilities. These facts coming in a deluge as they have dovetail together amazingly.

From this flood of detail an overall general concept of how cattle grow and develop has finally emerged. To understand linear measurements and their values, we have to first understand this concept. It's like a revelation. Once you put the facts together, its suddenly all clear! I don't have time in my oral presentation to touch on some of these more important papers that have so influenced Skip and I in our endeavor. I think, however, I'd be remiss if I didn't briefly allude here in this written summary to some of these new concepts that set us on the course we've taken. Hopefully this will give the sceientists in the group who question the merits of linear measures a chance to study these additional papers that are much more scholarly than this one.

A REVIEW OF THE LITERATURE

Much research has now shown that all animals of a species are alike in terms of skeletal composition, muscle placement and muscle proportion. In other words, anatomy is constant. The skelton of one grown beef cow is very similar to that of another grown beef cow -- except perhaps for overall size. No one denies that two bones on one skelton attach the same as they do on another skeleton. Similarly the same muscles or muscle groups exist on each, and they attach to the same bones at the same points. You can't say, for instance, that one bull's stiffle carries down lower than another's.

Dr. Rex Butterfield's work in Australia showed that the various muscle systems between animals of the same species are proportional. The USDA work at the Meat Animal Research Center at Clay City, Nebraska, reinforced Butterfield's work dramatically.

The carcass studies on over 1,100 steers in this project at MARC involved many different breed crosses. Their data encompassed such extremes in sizes as Jersey sires crossed on both Hereford and Angus cows as well as Simmental and Charolais sires crossed on these same cow breeds. Straight Herefords and Angus as well as Hereford Angus crosses were also used. All of these steers were slaughtered at the same physiological age -- that is when, as nearly as possible, each animal had a 5% chemical fat composition in the rib eye muscle (corresponding to the USDA choice grade). Naturally the various breed crosses had to be killed at different weights to obtain equal degrees of fat. When they were, however, the body composition of all crosses were almost identical. (See Table 1.)

Dr. Bob Koch's work here at the University of Nebraska again bore this MARC and Butterfield research out exactly. Koch's study involved breaking down one half of each of these same carcasses by their various retail cuts. The proportions of each cut (when trimmed) against total percent of lean meat is unbelievably uniform. (See Table 2.) Again this work was based on data from over 1,100 steers ranging over at least three different frame sizes.

Dr. Topel's work feeding identical twin calves at Iowa State University under different types of rations again bears out this same fact that every animal is a predisposed genetic package to grow to a certain size and to carry so much finish at a certain weight regardless of when he gets there.

Dr. Judge's work with Hohlstein and Angus steers fed to the choice grade and Dr. Lidvall's work at Tennessee University feeding steers of various breeds and frame sizes to a constant grade all proved that there is really only one basic factor responsible for the difference in the growth or body composition of any two steers, bulls or heifers at a given age. That difference is the MATURE SIZE which the animals will attain if they are left alive to grow and develop.

Once you accept that fact you've got the concept of how cattle grow and why they grow as they do. The mature size an animal will fianlly attain dictates how efficient he feeds at any given weight. It dictates how tall he'll be at any given age. It controls how much fat or lean muscle he will carry at any given age.

Think on it. Grasp the fact that all this research indicates time and again that mature size dictates growth rate, and performance, and quality grade and you've got the one key concept necessary to breed and mold cattle to any given set of performance standards you want.

Ponder, if you will then, what a valuable tool we'd have if we could predict an animal's mature size at a year of age -- or better yet -- at weaning. We already established that skeltons are proportional. If this is true, then one measure should be about as valuable as another in setting our parameters. Practice and good sound reasoning slowly developed the measurement of height over the animal's hooks as probably the best, most practical one linear measurement.

This measurement over the hips has now been selected by many in the industry for several reasons. First, Dr. C. J. Brown's work at the University of Arkansas showed this measure is most highly correlated to performance of all the measures he took. This is probably true because it involves measuring the skelton over a solid ball and socket linkage that is less subject to flexing. It is thus a more repeatable measure and therefore more accurate. Animals are taller at the hips than the shoulders. Thus the hip measure gives us a wider spread and larger field of numbers with which to work. This reduces our percent of error in measuring. Finally, this is the area the average rancher has traditionally walked up to on a bull or cow to "size up" the animal.

SOME FACTS ON LINEAR MEASURES

Armed with this convincing mass of data we set out eight years ago to incorporate linear measurements in our records to help us fix performance. The first fact we discovered about how cattle grow is hard to believe -- yet it's the key to using linear measures. AT A GIVEN AGE BULLS OR HEIFERS GROW AT THE SAME RATE REGARDLESS OF FRAME SIZE. The work at Missouri University shows this and our work agrees. The ration can vary the growth rate slightly, but it's so little as to be almost negligible unless the animals are so underfed that stunting occurs. To prove this point we calculated the daily growth rate from 205 days to 365 days on the tallest ten bulls and the shortest ten bulls in each of our last four calf crops. We averaged the results for each group of bulls and the growth rates don't vary 1/1000 of an inch!

We ran the same figures on the shortest and tallest ten heifers over the same years. The average figures for growth per day again are identical to 1/1000 of an inch. Granted in our herd those figures involve only a spread from frame size 3.5 to 5.5 animals. The work by the Extension Service of the University of Missouri, however, bears out this phenomenon over thousands of cattle ranging from frame size 1 to frame size 7.

After some 20,000 measurements at our ranch we were prepared to draw up growth charts for hip heights on bulls and heifers at all ages clear to maturity. Understand, the arbitrary decision that there would be a two inch spread between each frame size of bulls at a year of age was made by Missouri University. The rest of the industry has just followed along. Table 3 shows that frame size chart for bulls. It's for hip heights whereas the Missouri work is for shoulder heights. Our work indicates, however, the same average daily growth rate for both measures. Table 4 shows this data for bulls of three frame sizes along with the expected growth rate each month. Notice the uniform growth rate for each frame size whether it be at 10 months or at 18 months. The chart shows the standard as adopted by the American Hereford Association. Table 4 points out a slight discrepancy in the American Hereford Association's growth rate for bulls from 12 to 18 months. It is self-correcting, however, at the end of six months. I think common sense plus the volume of measures involved would indicate our figures, which agree with the Missouri data are more proper.

As you can see a bull grows .033" per day from weaning to a year or 1" per month. With this one fact and measurement of the bull if you know his exact age you can predict his height at any point along his growth curve. For instance, a bull that was 48½" tall at 350 days will be 49" tall at one year; 53½" tall at 24 months; and 55" at maturity.

Table 5 shows a similar chart for heifers. To my knowledge this is the first such chart ever prepared for heifers. It is based on our work with consultation of some preliminary work now being conducted at Missouri. I'm fairly confident that the data on this chart from weaning to a year is quite accurate. I'm also confident of the accuracy of the mature sizes for each of the corresponding sizes at a year. The growth rates from one to two years are based on only those heifers we've kept over the past eight years. They involve somewhat fewer numbers and may be subject to slight adjustments as more data develops. I don't think, however, the figures will change much within those months.

Our studies indicate that calving heifers at two or three years of age can affect their total growth up to 1". The heifers that calve at two years appear to be under such stress from lactation that they immediately cease growth. The heifers calving at two years and nine months or 3 years of age, on the other hand, get to complete their growth before the first onset of lactation.

A study of these charts reveals another fact often overlooked. These animals attain most of their skeletal growth at a relatively young age. Heifers for instance have achieved 80% of their total growth at weaning. At a year they've attained 90%. At two years of age they are almost through growing. At somewhere between 2½ and 3 years of age all skeletal growth is completed. This is true for both heifers and bulls. Steers, of course, due to castration continue to grow throughout life.

A comparison of the growth charts of the bulls and heifers also reveals that the two inch differential between heifers and bulls of equal frame scores does not occur until twelve months of age. (See Table 6.) Due to the differing growth rates between the two sexes the differential varies at each month of age with the spread being only 3/4" at 205 days. After a year of age the spread stays pretty close to 2" on up through maturity.

As we mentioned before, maturity comes much quicker than most expect. The myth that big cattle are late maturing, achieving a lot of their growth at two, three or even five years of age is just that -- a myth. There may be some little difference in when these cattle mature, but its relatively small.

It becomes quite obvious that if this is how cattle grow, and if we can measure how they grow, then linear measures can become a tremendous tool in any breeder's herd.

Only a sensationalist or a fool could ever advocate taking up the tape measure and throwing away the scales. The tape measure, however, can be a tremendous compliment to the scales in any herd.

These next two charts (See Table 7 & 8) show statistically just how accurately these linear measures can be as predictors when carefully taken. This chart shows the correlation for the hip height of both heifers and bulls at 205 days with both their subsequent adjusted hip height and weight at 365 days. As you can see, the correlation for hip height at weaning to hip height at a year is quite high (.841 ± .02 for the bulls and .884 ± .02 for the heifers). This shows just how accurate these measures can be in predicting mature size. The correlation of weaning height to adjusted 365 day weight is moderate and certainly significant (.491 ± .06 for the bulls and .523 ± .06 for the heifers). These correlations taken over the immediate past four calf crops have been calculated on a pooled within year basis to remove any differences between the four years due to environment.

Actually on an individual year basis the correlation for weaning hip height to yearling weight has exceeded .71 on occasions. Over the past six years, however, the phenomenon of the interplay between intensive selection and nature's natural barriers at the extreme has served to reduce this latter correlation within our herd. Six years ago our standard deviation for the bulls in height was 1¼" and the standard deviation for weight was 96 pounds. In other words, two thirds of all the calf crop had measures within a 1¼" spread around the average height, and they had weights varying up to approximately 50 pounds on either side of the mean or average weight. Today, through selection--especially at the bottom end--over the past six years we've moved that average weight up the line 71 pounds and the average height up by 1¼ inches. Because of nature's limits on size at the upper end, with that selection we've now severely compressed the standard deviation in both characteristics. One standared deviation is now only .75 inch in height and 60 pounds in weight. We thus have a spread on either side of the mean of only 30 pounds and 3/8 of an inch. Consequently our correlations between the two measures are dropping.

I can't emphasize enough the importance of care, patience, and proper facilities in taking these measures. One reason I believe the correlations on heights have been so high in our work is all of these measurements have been taken for over eight years in one head chute on a level concrete slab floor by the same person. At times I've had to wait 10 to 15 minutes to get a skittish calf settled down in order to get accurate measures. I'm sure had we relied on some complacent hired hands or a few indifferent students our records would not now serve as the tool that they presently do.

For real accuracy these measures should be taken on a level floor with a measuring tool that has a level on the horizontal bar that's placed on top of the animal's hooks or shoulders. Anything less can lead to sizeable errors.

Linear measures can quickly allow a breeder to determine where an animal fits in his herd. He can perhaps more quickly relegate the animal to either his keepers or culls. The animal's measure also lets the breeder more accurately predict what that animal will do on a given ration over a given period of time. We find that these measurements are a tremendous advantage to us in sorting our cattle. We can sort bulls at weaning on this basis with great reliability for management purposes. It allows us to sort once at weaning and avoid the many sortings that usually occur later on, because one bull is getting either to small or too large to stay in the bunch.

The next chart (Table 9) shows probably the most valuable use we can make of linear measures. This chart shows the top ten bulls in our crop rated at 205 days - first by adjusted weight and second by height. It's quite obvious that by selecting for bulls with top weights and top heights at 205 days you can better predict the bulls that will have the highest 365 day weight than you can by using either of the two measures alone. An examination of the list reveals four bulls that look particularly good in both traits. Tattoos 789, 861, 860, and 791 ranked at the top in each of the ratings. A look at the 365 day data at the right shows they outperformed all the others at a year. Three ranked 1, 2 and 4 in the herd in 365 day weights and the fourth, 791, was our entry that won the high overall individual honors at the OSU bull test. The latter was, of course, on a different feeding regimen and weighed under different conditions.

It is interesting to notice that selecting the top ten bulls at weaning for height will produce almost as good an average 365 day weight as will the top ten by weight at weaning. In any case, the important point is the two measures together are a much better predictor than either is alone. Table 10 shows these results over a four year period. It is also shows that in three out of four years the tallest five calves in the top ten calves by weight at weaning outperformed the heaviest five on their 365 day adjusted weight.

Table 11 shows a summary of the performance of the past four years of heifer crops in a similar manner. Here it's interesting to note that in three out of four years combining the best ten heifers in performance at weaning using both weight and measure effectively selected a higher average 365 day weight than did the top ten at weaning in either height or weight alone.

In the case of the heifers, however, the tallest five out of the heaviest ten at weaning did not regularly outperform the heaviest five. I believe this is because the heifers are developed on a considerably more restricted diet than the bulls. This no doubt effectively limits the ability of these extreme top framed heifers of the crop to express their full potential for gain.

The second most valuable use of linear measures for us is in allowing us to make valid comparisons across herds. Since mature size controls so much of the performance and carcass traits a good measure on a heifer or bull of a known age in another herd lets us know where that animal would stack up in our herd. Frequently management practices and feed rations vary from herd to herd. A comparison of heights between two animals in different herds can give one a pretty good idea of how they'd compare in weight or performance under similar management conditions. This is of particular importance in comparing bulls handled on limited feed with those that have been on full feed.

A study of tables 3 through 5 will also show that as knowledge spreads about how these animals grow and at what rates they grow, the occassional breeder who lies or cheats about the age of his cattle will be easily exposed. Nothing could stop these cheaters more quickly than the widespread knowledge of these growth patterns.

In conclusion let me wave one warning flag. We now know that if slaughtered at the right point in his individual growth curve any beef steer of any frame size can have just about ideal carcass characteristics. True, the weight at which this occurs varies with each frame size, but most steers can be killed at some point in their life to have a yield grade 1 or 2 and choice marbling. When they do they'll cut out as well as any other steer. They'll also express as much muscling, as good a muscle-bone ratio, and nearly equal performance or efficiency of gain.

At what point then are we going to start drawing the line concerning what we'll call a "good yearling weight or measure"? So far, we still say the animal that wins the bull test is the best. In effect he's usually also the biggest. Should we consider drawing a line somewhere? Should we perhaps identify our cattle on test according to what frame size they achieve as they come off test without declaring a winner or passing judgement on what's best? The present design of our bull tests is exerting ever upward pressure on frame size.

Linear measures are a valuable tool to help us make a more rapid move in type. They can identify or bracket our cattle for performance and growth, but they aren't an answer by themselves. Always bigger can't continue to be always right once we get the average of our breeds big enough. Please don't misunderstand me. I don't think most breed averages are yet where they need to be. I do think, however, we now have some individuals in every breed that are too big if we attempt to move the averages all the way up to their size. Our show ring judges and our bull tests need to face up to the question.

In conclusion I'd like to leave you with a quote from Emerson. He says it much better than I can:

> "In many endeavors the line between success and failure is so fine that we scarcely know when we pass it -- so fine that we can be right on the line and not know it."
> -EMERSON

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TABLE 1

THIS STUDY INVOLVES DATA FROM 1121 STEERS
PUBLISHED BY USDA ANIMAL RESEARCH CENTER
(PROGRESS REPORT NO. 3 - APRIL 1976)

	Live Weight	Carcass Weight	% Bone	% Lean	% Fat	Muscle Bone Ratio
Straight Hereford	970	609	12.7	67.5	19.8	5.4:1
Jersey x Hereford & Angus	886	550	12.9	66.9	20.3	5.2:1
South Devon x Hereford & Angus	992	632	12.6	68.1	19.2	5.4:1
Charolais x Hereford & Angus	1107	704	12.9	70.9	16.2	5.4:1
Simmental x Hereford & Angus	1109	699	13.1	69.7	17.2	5.3:1
Average	1008	638	12.8	68.8	18.4	5.4:1

All of these steers were killed at the same physiological age -- when they had 5% chemical fat in the rib-eye (Choice grade).

TABLE 2

PERCENT OF TOTAL RETAIL PRODUCT*
IN EACH WHOLESALE CUT

	ROUND	LOIN	RIB	CHUCK	ROASTS & STEAKS
HEREFORD X ANGUS	25.8	14.8	9.3	30.3	51.6
JERSEY X HEREFORD X ANGUS	24.7	15.1	9.7	30.7	52.0
SOUTH DEVON X HEREFORD X ANGUS	25.7	15.1	9.5	29.9	51.2
LIMOUSIN X HEREFORD X ANGUS	26.6	15.1	9.3	29.8	51.1
CHAROLAIS X HEREFORD X ANGUS	26.5	15.1	9.4	29.8	51.2
SIMMENTAL X HEREFORD X ANGUS	26.4	15.0	9.2	30.1	51.2
AVERAGE	26.0	15.0	9.3	30.1	51.4

*Retail Product is red meat with bone removed and fat trimmed to .3" outside fat.

Data presented by Dr. Robert M. Koch, Univ. of Neb. at the Range Beef Cow Symposium, Chadron, Nebraska 1977.

TABLE 3

FRAME SCORES FOR HEREFORD MALES					
Age In Months	Frame Score 1	Frame Score 2	Frame Score 3	Frame Score 4	Frame Score 5
5	34.00	36.00	38.00	40.00	42.00
6	35.00	37.00	39.00	41.00	43.00
205 Days	35.75	37.75	39.75	41.75	43.75
7	36.00	38.00	40.00	42.00	44.00
8	37.00	39.00	41.00	43.00	45.00
9	38.00	40.00	42.00	44.00	46.00
10	39.00	41.00	43.00	45.00	47.00
11	40.00	42.00	44.00	46.00	48.00
12	41.00	43.00	45.00	47.00	49.00
13	41.50	43.50	45.50	47.50	49.50
14	42.00	44.00	46.00	48.00	50.00
15	42.50	44.50	46.50	48.50	50.50
16	43.00	45.00	47.00	49.00	51.00
17	43.50	45.50	47.50	49.50	51.50
18	44.00	46.00	48.00	50.00	52.00
19	44.25	46.25	48.25	50.25	52.25
20	44.50	46.50	48.50	50.50	52.50
21	44.75	46.75	48.75	50.75	52.75
22	45.00	47.00	49.00	51.00	53.00
23	45.25	47.25	49.25	51.25	53.25
24	45.50	47.50	49.50	51.50	53.50
MATURITY	47.00	49.00	51.00	53.00	55.00

TABLE 4

FRAME SCORES FOR BULLS

AGE	FRAME 3	FRAME 4	FRAME 5	GROWTH/MONTH
6 Months	39.00	41.00	43.00	1"
205 Days	39.75	41.75	43.75	--
7 Months	40.00	42.00	44.00	1"
8 Months	41.00	43.00	45.00	1"
9 Months	42.00	44.00	46.00	1"
10 Months	43.00	45.00	47.00	1"
11 Months	44.00	46.00	48.00	1"
12 Months	45.00	47.00	49.00	1"
13 Months	45.50	47.50	49.50	*3/4"
14 Months	46.00	48.00	50.00	*3/4"
15 Months	46.50	48.50	50.50	1/2"
16 Months	47.00	49.00	51.00	1/2"
17 Months	47.50	49.50	51.50	*1/4"
18 Months	48.00	50.00	52.00	*1/4"
19 Months	48.25	50.25	52.25	1/4"
20 Months	48.50	50.50	52.50	1/4"
21 Months	48.75	50.75	52.75	1/4"
22 Months	49.00	51.00	53.00	1/4"
23 Months	49.25	51.25	53.25	1/4"
24 Months	49.50	51.50	53.50	1/4"
AT MATURITY	51.00	53.00	55.00	----

*RATE SHOWN UNDER GROWTH RATE IS MORE CORRECT

TABLE 5

FRAME SCORES FOR HEREFORD FEMALES					
Age In Months	Frame Score 1	Frame Score 2	Frame Score 3	Frame Score 4	Frame Score 5
5	33.75	35.75	37.75	39.75	41.75
6	34.50	36.50	38.50	40.50	42.50
205 Days	35.00	37.00	39.00	41.00	43.00
7	35.25	37.25	39.25	41.25	43.25
8	36.00	38.00	40.00	42.00	44.00
9	36.75	38.75	40.75	42.75	44.75
10	37.50	39.50	41.50	43.50	45.50
11	38.25	40.25	42.25	44.25	46.25
12	39.00	41.00	43.00	45.00	47.00
13	39.75	41.75	43.75	45.75	47.75
14	40.25	42.25	44.25	46.25	48.25
15	40.75	42.75	44.75	46.75	48.75
16	41.25	43.25	45.25	47.25	49.25
17	41.75	43.75	45.75	47.75	49.75
18	42.25	44.25	46.25	48.25	50.25
19	42.50	44.50	46.50	48.50	50.50
20	42.75	44.75	46.75	48.75	50.75
21	43.00	45.00	47.00	49.00	51.00
22	43.00	45.00	47.00	49.00	51.00
23	43.25	45.25	47.25	49.25	51.25
24	43.25	45.25	47.25	49.25	51.25
MATURITY CALVED AT 2	44.00	46.00	48.00	50.00	52.00
MATURITY CALVED AT 3	45.00	47.00	49.00	51.00	53.00

TABLE 6

COMPARATIVE FRAME SCORES FOR BULLS AND HEIFERS

AGE	FRAME 5 BULLS	FRAME 5 HEIFERS	DIFFERENCE
6 MONTHS	43.00	42.50	.50
205 DAYS	43.75	43.00	.75
7 MONTHS	44.00	43.25	.75
8 MONTHS	45.00	44.00	1.00
9 MONTHS	46.00	44.75	1.25
10 MONTHS	47.00	45.50	1.50
11 MONTHS	48.00	46.25	1.75
12 MONTHS	49.00	47.00	2.00

BULL GROWTH CORRELATIONS

(157 HEAD)

	365 DAY HT.	365 DAY WT.
205 DAY HT.	.841	.491
STANDARD ERROR	± .023	± .060

(Pooled Within Year Correlation 1975-8 Calf Crops)

TABLE 8

HEIFER GROWTH CORRELATIONS

(134 HEAD)

	365 DAY HT.	365 DAY WT.
205 DAY HT.	.884	.523
STANDARD ERROR	± .019	± .062

(Pooled Within Year Correlation 1975-8 Calf Crops)

TABLE 9

BULL CALVES - 1978 CALF CROP

BULL	205 DAY WEIGHT	205 DAY HEIGHT	365 DAY WEIGHT	365 DAY HEIGHT
HEAVIEST TEN CALVES AT 205 DAYS:				
789*	695 (1)	43.0 (6)	1176 (4)	48.5 (5)
818	673 (2)	42.2	1153 (7)	47.2
861*	671 (3)	43.8 (2)	1207 (1)	49.5 (1)
860	659 (4)	43.7 (3)	1188 (2)	49.0 (4)
855*	654 (5)	42.4	1170 (5)	47.4
838	643 (6)	41.8	1153 (7)	47.6
791	638 (7)	43.6 (4)	1132 OSU	49.1 (3)
785	635 (8)	41.1	1067	45.9
833	633 (9)	43.1 (5)	1034	48.5 (5)
834	633 (9)	41.9	1116	47.1
AVERAGE	653	42.7	1140	48.0
TALLEST TEN CALVES AT 205 DAYS:				
851	601	44.2 (1)	1084	49.2 (2)
861*	671 (3)	43.8 (2)	1207 (1)	49.5 (1)
860	659 (4)	43.7 (3)	1188 (2)	49.0 (4)
791	638 (7)	43.6 (4)	1132 OSU	49.1 (3)
833	633 (9)	43.1 (5)	1034	48.5 (5)
789*	695 (1)	43.0 (6)	1176 (4)	48.5 (5)
819	624	42.8 (7)	1076	48.2 (10)
829	630	42.8 (7)	1148 (10)	48.5 (5)
858	622	42.7 (9)	1073	48.4 (8)
803	571	42.5 (10)	1151 (9)	47.5
AVERAGE	634	43.2	1127	48.6

*Out Of A Heifer

TABLE 10

VARIOUS YEARLING AVERAGES BASED ON 205 DAY PERFORMANCE (157 BULLS)

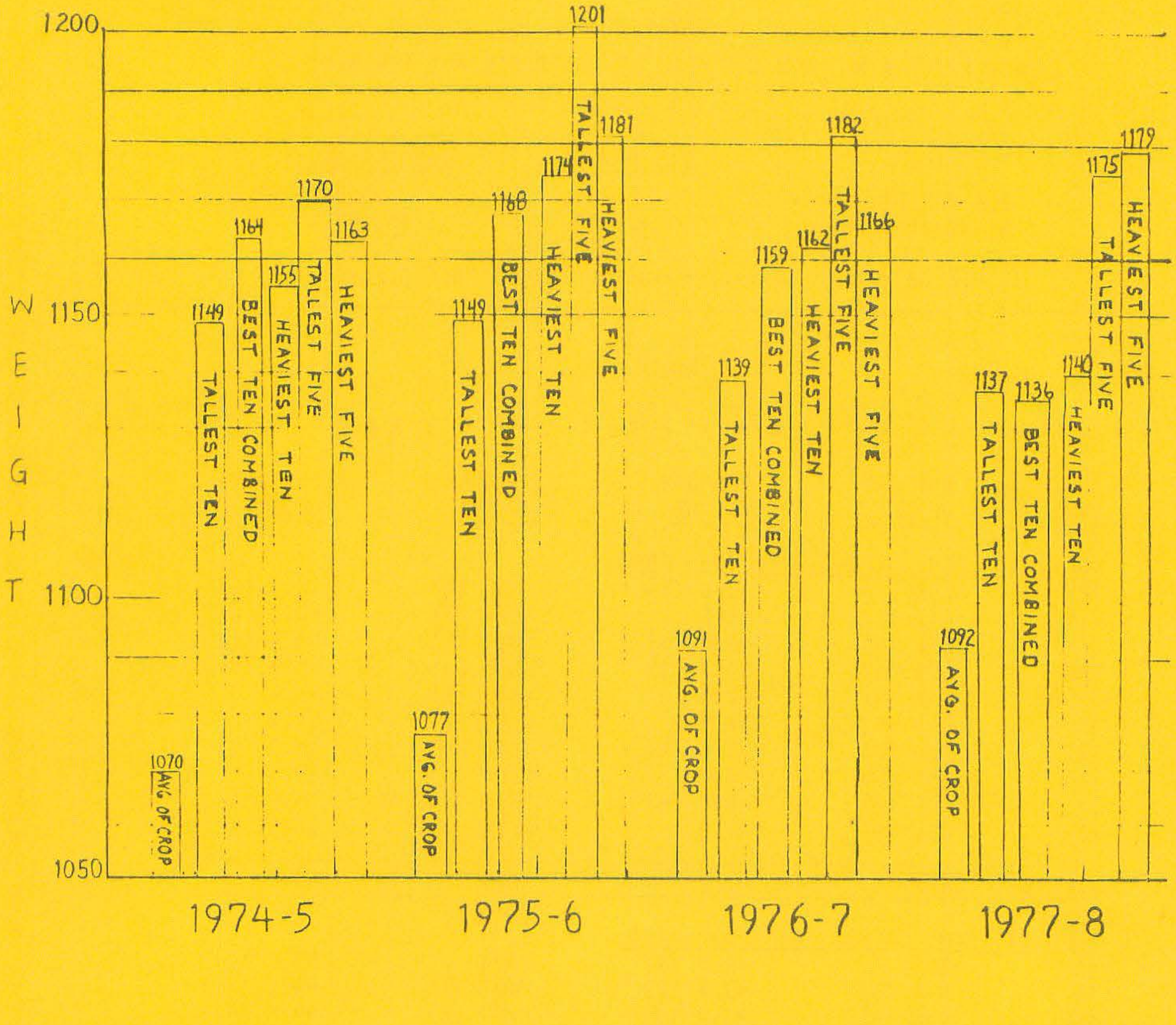
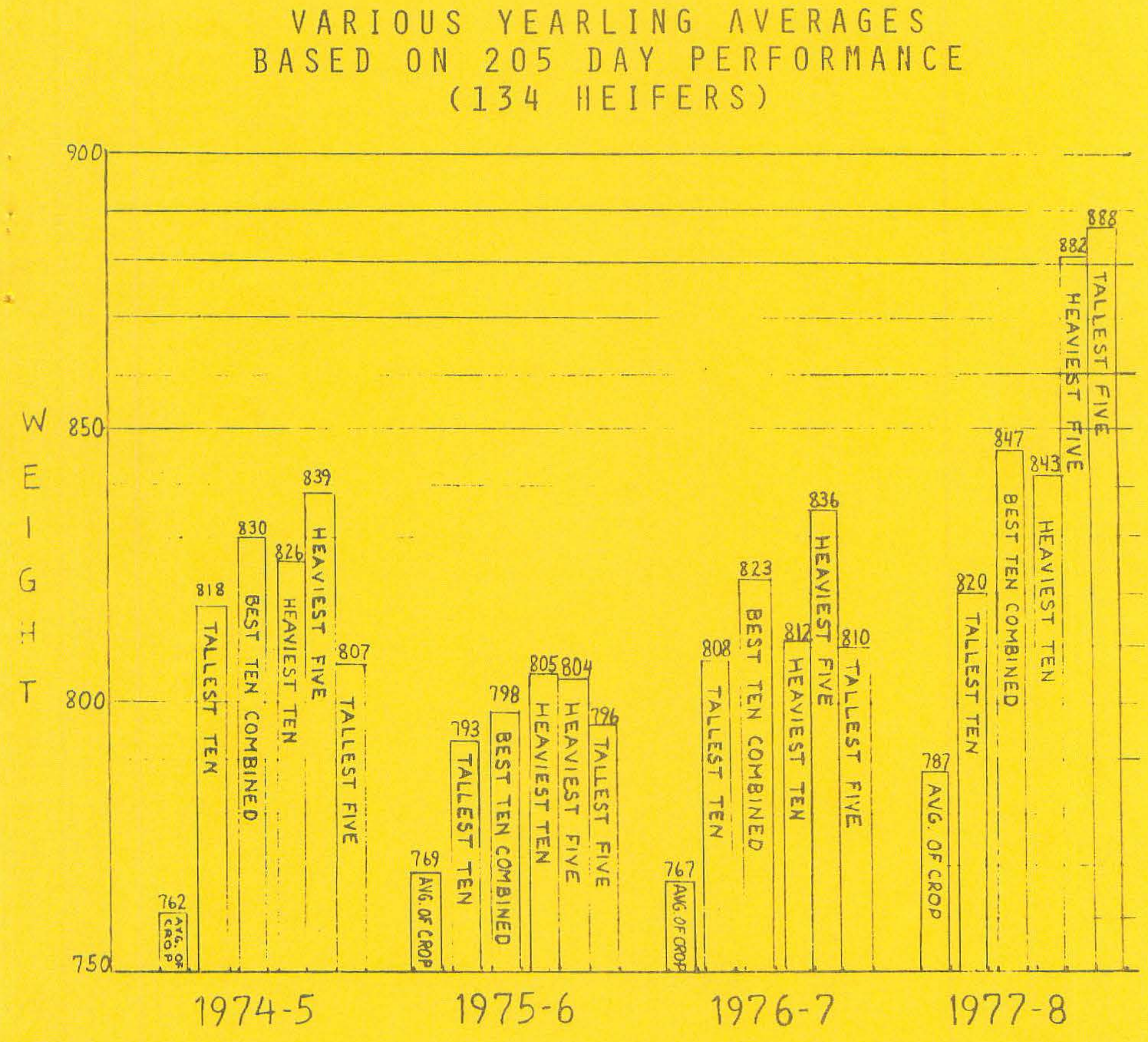


TABLE 11


VARIOUS YEARLING AVERAGES
BASED ON 205 DAY PERFORMANCE
(134 HEIFERS)
WEIGHT
900
850
800
750
1974-5
762 AVG. OF CROP
818 TALLEST TEN
830 BEST TEN COMBINED
826 HEAVIEST TEN
839 HEAVIEST FIVE
807 TALLEST FIVE
1975-6
769 AVG. OF CROP
793 TALLEST TEN
798 BEST TEN COMBINED
805 HEAVIEST TEN
804 HEAVIEST FIVE
796 TALLEST FIVE
1976-7
767 AVG. OF CROP
808 TALLEST TEN
823 BEST TEN COMBINED
812 HEAVIEST TEN
836 HEAVIEST FIVE
810 TALLEST FIVE
1977-8
787 AVG. OF CROP
820 TALLEST TEN
847 BEST TEN COMBINED
843 HEAVIEST TEN
882 HEAVIEST FIVE
888 TALLEST FIVE

Inherent Dangers of Linear Measurements
By Dr. Robert C. de Baca* and Michael Mc Inerney**

There are no dangers in linear measurements themselves except in getting kicked while taking them. Linear measurements come in all shapes and sizes.

Some are straight, some are horizontal
Some are circular, some are verticle
Some have had lots of research
Some appear to have very little
Some have justification
Some seem to have none.

The most common linear measurements one hears about are:

Backfat
Length of body
Height at withers
Height at hips
Circumference of testicles
Circumference of heart girth
Pelvic size

They tell the story of a fellow who had two horses - - and he couldn't tell them apart - - so he measured them. The black was an inch taller than the white one.

In studying research methodology - - I liked the NULL HYPOTHESIS - - that there are no differences among the treatment means - - and then you try hopefully to disprove it. In our courts of law in this land a person is considered INNOCENT until proven guilty. So it should be with new concepts. Research should prove or disprove.

One researcher meticulously and routinely took 185 measurements on multitudes of cattle - - wrote 15 publications, drew few conclusions, reported 464 heritability estimates in one publications, proved no justification for them, then recommended their use - - to be more fully employed in bulls than heifers.

I had my bulls measured this year. The tall ones all measured higher than the short ones. My tallest one was within .03 of highest weight per day of age so I kept him. I don't yet know which was the best bull genetically, but I'm not sure it was the tallest one. The correlation of weight per day of age and hip height on my bulls was .71. The tall ones sold highest. We appreciated the dollars but think conventional wisdom was part of the selection criterion.

* Huxley, Iowa 50124, paper was presented by de Baca
** Iowa State University, Ames, IA 50010

Some of the earliest solid data on measurements and their relation to production traits were from the Miles City Experiment Station. They are reported below.

CORRELATIONS - PERFORMANCE AND CARCASS TRAITS

WOODWARD, et al, 1969

ARS, MSU Bulletin 550

	Birth weight	180 day wean wt.	ADG	Final wt.	Carcass grade
Length of foreleg	.31	.45	.40	.51	.--
Length of body	.42	.57	.54	.68	.11
Length of hindleg	.43	.59	.55	.71	.03
Width of Shoulders at 1st rib	.24	.38	.65	.68	.34

Their summary statement was: "There were no correlations between production characters and carcass traits high enough to have much predictive value."

Now if using the above table, we assume a 60% heritability for growth to market weight and a 70% correlation between growth and height; then, $.7^2$ equals .49, so one can infer that roughly 50% of the variation in growth is accounted for by variations in height AND 50% of 60% heritability is 30% which would be the effective heritability if we use an indicator - - height - - to predict growth.

The coauthor of this report did a vast literature review for me. One was sorely needed. Ours will be made available for publication in the BIF summary. Our conclusion is that the scientific literature at this time does not support, substantiate nor justify the use of structural linear measurements. As a matter of fact the scientific literature is rather void of any substantive scientific fact about structural linear measurements. I am told that some fairly solid data do exist but they are not published in recognized refereed scientific journals in the normal manner in which scientists report research. I must hasten to add that research reports do not indicate that structural linear measurements should NOT be used or useful. I have no personal quarrel with linear measurements being taken or not taken, nor with the people who have strong personal and emotional regard for them and I am on no crusade. As a matter of fact I am in the business of breeding and selling cattle and this interpretation will be no more popular than the strong stand I took for performance testing 20 to 25 years ago.

But I do have serious reservations about how measurements will be used or misused in breeding programs and particularly in the psychology of selling. This misuse is one of our greatest dangers.

The inherent danger of linear measurements are:

1. Sidetracking the functional efficiency goal.
2. Setting them up as the goal.
3. Correlated responses of delayed reproductive maturity, delayed compositional maturity, exceptional maintenance requirements.
4. That they will be most misused by those who follow fads rather than those who attend BIF conferences.

Reported heritabilities for height in the literature are as follows:

Arapovie - Yugoslavia (ABA	.52		withers yr. bulls
Grabaski - Poland (ABA)	.33		withers cows
Grabaski - Poland (ABA)	.25		hip cows
Newman - Germany (ABA)	.14	.40	withers yr. bulls
Kogel - Germany (ABA)	.21		withers yr. bulls
Udris - Denmark (ABA)	.45		withers heifers
Massey, Missouri - (SD Farmer)	.45	.50	hip (yearlings)
Massey, Missouri - (SD Farmer)	.55	.65	wither (yearlings)
Brown, Arkansas - (Bulletin 597)	.29		withers Hereford calves
Brown, Arkansas - (Bulletin 597)	.38		withers Angus calves
Green, Maryland - (Bulletin A188)	1.03		Angus bull calves
Green, Maryland - (Bulletin A188)	1.21		Angus bull yearlings
Green, Maryland - (Bulletin A188)	.51		Angus heifer calves
Green, Maryland - (Bulletin A188)	.47		Angus heifer yearlings
Dawson, USDA - (JAS)	.65		Milking SH steers

Several researchers have questioned the accuracy of measurements or indeed the repeatability of measurements. Most of the reported data on these are in dairy cattle. However, Green and Cameron reported a repeatability of .85 on height. Orme and coworkers report .96. On my own bulls, Dr. Brackleberg had a .93 correlation between wither and hip measurements. On an Iowa Polled Hereford herd recently, two scientists had a 30% correlation between their measurements, and one had a .61 correlation between first measure and running them back through for a second measurement. I guess some can measure and some can't.

Colorado scientists recently reported the correlations shown below:

CORRELATIONS (Colorado)
Gibb, Taylor and Knievel

Back fat and carcass fat - - - r = .92

Height at Withers

Slaughter age	.20
Hot carcass weight	.23
Length of body	.41
Length of hip	.44
Length of rear cannon	.45
Length of head	.81
Actual backfat	- .31
% retail yield	.30
Lean yield/day	.23
Carcass weight/day	.26
Marbling score	- .38

Brown, Brown and Butts, 1973 of Arkansas reported the following correlations:

GENETIC CORRELATIONS

		Pre Weaning Gain 4 mo. - 8 mo.	Test Gain 4 mo. - 8 mo.	Final Wt. 4 mo. - 8 mo.
Wither Height	Herefords	0.87 - 0.77	0.85 - 0.49	0.85 - 0.58
	Angus	0.66 - 0.70	0.31 - 0.68	0.48 - 1.05
Hip Height	Herefords	0.77 - 1.15	0.83 - 0.97	0.76 - 0.78
	Angus	0.77 - 0.83	0.33 - 0.57	0.59 - 0.86

PHENOTYPIC CORRELATIONS

Wither Height	Herefords	0.30 - 0.40	0.28 - 0.10	0.26 - 0.30
	Angus	0.18 - 0.28	0.19 - 0.19	0.30 - 0.52
Hip Height	Herefords	0.29 - 0.49	0.18 - 0.23	0.24 - 0.38
	Angus	0.21 - 0.52	0.22 - 0.34	0.32 - 0.53

I feel particularly uneasy about well trained University and breed people espousing measurement methods "because they are a popular part of current conventional wisdom" or because people want them. Professionalism demands greater objectivity. Can professionals stand idly by and let the right answer be given to the wrong questions? I'm saying we need data and WE NEED IT SOON and we shouldn't be making recommendations until the data are in - - solid, justifiable and refereed. And such publications as our own Ideal Beef Memo, or Farm Journal, or the Simmental Shield or the Dakota Farmer or the Drover's Journal are not refereed journals. No - - I have no quarrel, but I say "prove it to us - - WITH DATA."

Yes, the research reports show that the heritabilities of many of the structural linear measurements are high. But the question is "are they indeed relevant?" (Just because a trait is heritable doesn't mean its useful.) Will their use sidetract the main issue? Does it make sense to select for correlated traits when you can select directly for main effects? Does it make sense to select for correlated effects when indeed the trend is to adjust the correlated trait for main effects in order to select the correlated effect which in turn is used to predict the main effect? For example: It is logical in an era where performance breeding is not totally accepted and adjusted weights are disliked by many; to adjust height measurements for differing growth rates so as to get a more reliable estimator of ultimate growth potential?

Brown in a Hereford Journal article indicated the correlation of mature weight and rate of maturing for weight is -.95. Further he said:

"The genes which increase mature weight will tend to slow the maturity for weight. Therefore, breeders who are selecting for larger mature weights also are selecting for a reduced rate of maturing for weight." IS THIS WHAT WE WANT?

I have very much liked the Wisconsin data that was done on Angus, Hereford and Charolais cattle several years ago by Val Brungardt. It gave us many insights that we needed. It showed us things about compositional maturity and its relation to efficiency. It put many things in perspective. I like to have people describe cattle to me on the phone as to body type. However, I think we are having a tendency to go overboard on the small amount of data. Let's analyze the body types and see if we're not playing with another right answer to a wrong question. Just like the showring champions of recent years and their owners are embarrassed by the showring champions and their pedigrees in the late 50's and early 60's, the various types are reflective of those same differences. The 4's and 5's of the Angus and Hereford groups were from herds who had been on performance programs where length and height came on as correlated responses - - the 1's and 2's were reflective of the old-pedigree herds. And their response in growth and carcass was just what previous research would have predicted. The "research" was more practical application than "basic", but very well done and timely. The 6's and 7's in the Charolais trial were merely the 4's and 5's plus the breed effect of Charolais. None were selected for height - - the form resulted from function; and I fear we could easily interpret the form, set it up as our goal and hope that function will follow it. This is another of the greatest dangers.

Indeed, if breeders can set up to utilize linear measurements to complement instead of replace the main issues, then they might be good. I think function can come in varying shapes, Dave Nichols, What do you think? Our tendency is to pick a form and hope function will follow. I had not seen a good report or description of use of structural linear measurements until I received the Healey sale catalog earlier this year. My interpretation is that they want to produce high-performing Type 5 cattle. They will probably accomplish it. They will give up something in performance along the way by forcing in another trait. And it is not them that I'm worried about - - but those who taut the height measurement, buy pages of four color spreads and belong to neither their state nor breed improvement program and hire sale managers who write untold paragraphs that say nothing and confuse or impress many. I'm fearful of having an industry's goals being side tracked even though we do live in a country where every one has a right to make or lose money as he wishes. I become disillusioned that our "doctoral betters", using Colin Kennedy's usual put down, might encourage rather than discourage the correct decision.

Today some people are now predicting finished weight with Body Type or Frame scores. Find me a packer buyer who will pay me for choice grade on blind faith of weight per score. I think I can do as well knowing the average weights of the dams on both sides of the pedigree.

Besides that I'm told that height is the No 1 criterion determining semen sales in certain studs. The first thing some breeders tell you about their bull is how tall he is. And some of these same breeders neither participate in breed or state beef improvement, nor in National Sire Evaluation nor do they allow a stud to enter their bull in NSE if the bull is in the stud.

It is interesting to hear similar observations about showring placings from certain breed secretaries or breed reps. One told me that the correlation on the bull classes is almost perfect. Observe a study of 1978 and 1979 Hereford bull classes at the Denver Stock Show:

HEREFORD BULLS

NATIONAL WESTERN STOCK SHOW 1978 - 1979

(Connie Bartelma, Iowa State)

Correlations Hip Height and Weight/day of Age.*

	1978	1979
Spring calves	.42 (22)	.54 (26)
Junior calves	.51 (37)	.52 (19)
Senior calves	.23 (12)	.40 (19)
Junior Yearlings	.29 (7)	.40 (28)
2's	-.31 (12)	-.01 (14)

* High positive correlation would supposedly be ideal.

Correlations Hip Height and Placings**

Spring calves	-.73	-.79
Junior calves	-.30	-.49
Senior calves	-.70	-.94
Junior Yearlings	-.49	-.90
2's	-.38	-.42

** High negative correlation would supposedly be ideal.

Correlations WDA and Placings**

Spring calves	-.23	-.45
Junior calves	-.44	-.35
Senior calves	-.64	-.29
Junior yearlings	-.35	-.76
2's	-.10	-.67

** High negative correlations would supposedly be ideal.

I guess I don't want to be forced in my/our breeding program to shape cattle a certain way at the expense of utility because of conventional wisdom. Are you analyzing this aspect with all professional honesty or are you letting expediency guide you? Is, indeed, the "one more tool" justified or is it a way to sidestep controversy?

I cannot participate in the belief that because some herds need more scale and stature that our seedstock herds need to resort to extremes to play catch up. Let them crossbreed their way out. Nor can I agree with the statement once made to me by a state extension specialist, "I can get people to measure easier than I can get them to weigh." Is that a right answer to a wrong question? Then should we try to make Angus and Herefords look like Charolais and in fact make Charolais and Limousin become Chianina formed? How far conventional wisdom?

In summary, therefore our conclusions are:

We ARE NOT told by the data that structural linear measurements will bring about improved fertility or reproductive efficiency; as a matter of fact, there are inferences to the contrary.

We ARE NOT told by the data the linear measurements will bring about improved mothering ability nor milking ability.

We ARE told by the data that linear measurements will bring about improvement of growth rate or feedlot performance as a correlated response at about half the rate as selection directly for growth.

We ARE told by the data that selection on linear measurements will bring about delayed maturity - - hence delayed compositional maturity though most of the data were taken on body types measured "after the fact" rather than resulting from direct selection - - so we interpret and believe that direct selection such as currently recommended and being verified in National Sire Evaluation will accomplish the same goal - - perhaps more reliably.

We ARE told however that linear measurement of testicle size is a reliable method of determining potential semen producing ability of bulls. This is probably the most important linear measurement and it is circular.

In this era when "tall is good" and we're breeding cattle for deep mud," it behooves the cattle industry to look objectively at where its gene pool is headed. An industry should use every sound tool available to help make progress, but no tool should become the goal if it is not indeed the trait of final importance. We should look around and see that - - Yes - - today's cattle are taller. Yesterday's short cattle and their embarrassing pedigrees have been discarded. The performance cattle are taller - - and so are those that are suspect of having cousins in other breeds. In the Hereford breed it is indeed the performance-bred cattle that have an edge on height. Height came as a 30 year correlated response in the Miles City cattle, in the Prospectors and in the Jones cattle and other lines. In the Angus, I dare say the extremely tall cattle have been less apt to win in sire evaluation or to top a test station evaluation.

So at the risk of being repetitive, the inherent dangers of measurements are not the measurements or their use, but rather:

1. That the goal of functional efficiency be sidestepped in the quest of height which is an indicator trait.

2. That correlated responses of delayed compositional maturity and high maintenance costs could be more damaging than the increases in structural dimension are good.

3. That structural measurements will be more subject to misuse by those who do not participate in state and breed programs than by those who do participate.

Our educational leaders have a responsibility to straighten out our doubts and lead us in the right direction - - before industry recommendations are made in the absence of substantive data.

Perhaps the most interesting comment which we found in the scientific literature was one a summarizing one by Brown, Brown and Johnson (April 1979) from Arkansas. It bears out the contention of this report as follows:

"In these data the relationships of body dimensions with performance did not change as a result of selection for a different kind of beef animal indicating little additional information is provided from body measurements when performance data are available at either 84 or 140 days of test ...."

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PRESIDENT'S ADDRESS

James Bennett

May 1979

Lincoln, Nebraska

Art and I discussed this B.I.F. program late last winter, and at this time I was told that following the Tuesday luncheon would be my responsibility for a few remarks. At that time, my plans were to use my oldest son, Paul, since he is familiar with and practices performance testing. He had a speech, and it was a winner. Paul attended the B.I.F. meeting in Virginia last year and had made plans to attend this meeting until recently when a conflict developed. At this point, I share with you the concern that Paul is not here.

A year ago, the High School F.F.A. boys had to write and give a speech in competition on the local level. From here, the winner would compete in the Federation. Before Paul gave his speech, his instructor asked if he might read it since he expected him to have a good chance to win. After the instructor read the speech, he suggested it was an excellent speech and obvious that Paul knew his subject, but it was not a winner since it was on Performance Testing and this was a narrow subject that his judges would know very little about. He suggested Paul select another topic and write another speech that could be a winner. After thinking about it for a couple of days, Paul decided to use the speech he had since he felt comfortable with it and believed in what he was talking about. He won the local chapter contest, the Federation, the District and was third in the State contest.

Now this is the point I want to make - why would performance testing be a narrow subject? These judges were no strangers to agriculture. They are usually extension people, vocational agriculture instructors, agricultural loan officers, or, at least, agriculturally oriented people. One of our great challenges in our performance testing program has been, is, and will be education. Now if you don't think this is a continual process, just check with any of our breed associations and determine the average time a purebred breeder is in business. According to one of our major breeds represented here today, it is seven years. In less than seven years you don't have time to develop a long range performance program. In fact, one of our slogans at Knoll Crest Farm is "predictable performance comes only after years of planned performance." Regardless of how new a breeder is, he can capitalize on my years of planned performance, and this is what I am trying to sell him on. I find it is a rather lonesome and expensive task to try to get this education across in slick paper advertisement. From looking at the ads in almost any breed magazine, it is evident that not many breeders are long suited in the performance field.

I am not sure whether the lack of use of performance records in many purebred herds is a case of don't know or don't care. I witnessed evidence at the Wye Plantation Sale and the R. W. Jones dispersal to know the beef cattle industry is waiting for someone to develop a set of superior performance tested cattle and will reward them financially for doing so.

Two years ago, I watched with real interest the dispersal sale of two herds of cattle. These two breeders had used performance records and performance testing to build probably the top herd in each of their respective states. Throughout the advertisement of these sales, the sales management capitalized on the length of time and extensive use of performance records in developing these herds. Each breeder had tested bulls through their Central Test Station for several years and were consistently at the top end.

This seemed an opportunity for my two sons, aged 15 and 16 at the time, who had leased a neighboring farm and started a small herd of registered Polled Hereford cattle, to add some cows with outstanding performance records. They acquired a dam summary and in turn picked out the top twenty cows in each herd on performance records alone, not considering any cow below 110 ratio. We visited each herd before the sale and eliminated several head from each of the two groups. Come sale day, it was evident that this would be payday for performance testings due to the large crowd and their interest in the cattle, and it was.

When the sale started, I learned why no records were published. These people were here to capitalize on a performance tested herd, but they didn't want records that would interfere with their better judgment, eye appeal.

The cow pictured on the front of one sale catalog was a 83 ratio cow on five calves, although she really had eye appeal. Out of the four or five hundred people, I don't believe you could have picked a jury of twelve cattlemen who would have sentenced this cow to death, even though there was enough evidence against her. Of course, I wouldn't be too critical of a cow having five calves at 83 ratio. I would blame her for her first low ratio calf, but any beyond that, it is the responsibility of her manager.

The boys' homework really paid off. In the two sales, they purchased sixteen cows with an average ratio of 115.8. Now this is the shocker ---- the average cost was only $28.00 more than the average of the rest of the cows sold.

What is really the hangup that is keeping many purebred breeders from getting involved on a performance testing program? Is it record keeping? Let me share with you a typical example on attitude toward records. This is observed at a recent B.C.I.A. meeting at Clemson, South Carolina. The meeting was a two-day educational program on performance testing. Our first morning session was at the University on the use and application of performance records. After lunch, we were taken out to the Bull Test Station where we were to have a practical application which was divided into two parts. We gathered in the sale barn where the handouts were given to us and explained how to complete them. Included was performance data on twenty cows; they were divided into 10 groups, 2 cows in each group. Also, we had performance data on 20 heifers; 10 groups with 2 in each group. The exercise involved selecting for breeding purposes 10 cows, 1 from each group. Also picking 10 heifers, 1 from each group by use of records only. Another form was to be completed by selecting 10 cows and 10 heifers on visual appraisal alone from 10 groups, 1 in each group, on cows and heifers just outside the sale barn. At this point, we were dismissed for one hour in order to complete these practices. The interesting part was that I was one of four people who chose to remain on the seats and complete the record portion of the exercise first. The other 96 people crowded out the door and around the pens doing what they liked best, visual appraisal. Thirty minutes later as they came back into the sale barn, we went out and completed our visual appraisal. When I was on the program the following morning, I pointed this out as a typical example of the cattleman's attitude towards records -- and this was at a B.C.I.A. meeting.

If the performance program is going to survive and grow to it's need and potential, someone is going to provide a lot of missionary work and it needs to be done at the state level. The term "missionary work" reminds me of the first B.I.F. meeting I attended. While having breakfast with two long-time performance breeders, one commented to the other, "This B.I.F. organization is a pretty generous group. Wonder why we do all this missionary work instead of taking this information and run off and leave the other breeders?"

No, the situation has not changed. We are still a generous group and hopefully a responsible group. But how do we fulfill this responsibility? From time to time I hear the concern expressed that our state B.C.I.A.'s are losing ground due to the many breeders turning to their breed association to have their records processed. I see no reason why our state B.C.I.A. cannot continue as a vital part of the performance program. Sure, our breed associations can and should develop and administer a detailed performance program on national level, but if it is to benefit the total purebred industry, a lot of missionary work will need to be done on the local level. You and I as purebred breeders need our state B.C.I.A. as much as ever. They are the logical group to provide this missionary work between the breeder and our national associations. There can be no let up on our "see and tell" or elementary education program. No way can our national breed associations sell and administer the performance program to the less aggressive or new breeders with local assistance. It seems logical that a working arrangement could be worked out where our state B.C.I.A.'s could assist our various breed groups and strengthen the purebred breeders, the state B.C.I.A., and the national breed groups all at the same time.

MINUTES OF BOARD OF DIRECTORS

BEEF IMPROVEMENT FEDERATION

The Lincoln Hilton

Lincoln, Nebraska

May 21, 1979

The meeting was called to order by President James Bennett at 7:00 a.m. on May 21, 1979. Those present included directors Martin, Spader, Butts, Berg, Ludwig, Farmer, Scarth, Keffeler, Nelson, Shaw, Bennett, Linton, Gosey, Eller, Hubbard, Baker and Cundiff. Also present was Randall Reed representing the Ohio Beef Cattle Improvement Association.

Motion Minutes

The reading of the minutes of the mid-year Board of Directors meeting was dispensed with since they had previously been circulated to the directors. It was moved by Ludwig and seconded by Nelson that the minutes be approved as circulated. Motion carried.

Finances

The financial report was presented along with a BIF membership list and the dues status of each. A discussion of the billing process followed. The following recommendations were made pertaining to the collection of dues:

1. Billings should be made on an official BIF billing form similar to those used by businesses. This should result in prompter attention to the payment of dues.

2. Addresses and officers of the member organizations should be updated from time to time so bills can be directed to the proper individual.

Convention Invitation

Randall Reed from Ohio State University was introduced. Ohio State University and the Buckeye Beef Cattle Improvement Association would like to host a national symposium on animal breeding and performance testing in 1980 and 1981. Randall graciously invited BIF to the Ohio

State Campus for its annual convention in one of those years in order to make the symposium and convention a joint activity. President Bennett thanked Randall for the invitation and assured him that he would be notified as soon as the Board has taken positive action.

Committee Reports

Nominating - President Bennett reminded Greg Martin and Jack Farmer that they were members of the nominating committee with Greg serving as chairman.

Revision of By-Laws - Sherm Berg, Don Nelson, Dixon Hubbard, Frank Baker and Art Linton were reminded that they had been appointed to serve on the by-law revision committee. A meeting of that committee was announced to be held at the conclusion of the BIF convention.

Awards

Art Linton notified the Board of the position of the U.S. Beef Breeds Council relative to the breed association of the year award. He had been notified by that group that they felt that this award had served its purpose and needed to be restructured. Greg Martin elaborated that the Beef Breeds Council was of the opinion that this should become a special recognition award to be given to a beef breed that took some bold and innovative steps in a given year. Frank Baker added a historical perspective to the entire BIF awards program. He stated that they were intended to give recognition to those deserving individuals and organizations, and to stimulate greater achievement in the area of beef improvement. President Bennett re-activated the awards committee of Greg Martin, chairman, Wayne Eschelman and Art Linton and added Frank Baker to that group.

New Business

Don Nelson brought up the matter of the Beeferendum. He stated that this act could well provide some badly needed funds for conducting beef cattle research. This should help BIF achieve the goals for which it was founded. Nelson moved, Dick Spader seconded, that the Executive Director draft a resolution in favor of the Beeferendum to be sent to the hearing clerk at the USDA and to the member BIF organizations. Motion passed.

The meeting was recessed until 7:00 a.m., May 22.

Respectfully submitted,

Art Linton

Art Linton
Executive Director

Financial Status

Beef Improvement Federation

	May 10, 1978	May 20, 1978
Cash on Deposit	$ 1,894.60	$ 3,095.94
Savings Account	8,589.13	9,999.72
Total Assets	$10,483.73	$13,095.66

Itemized Income

	Iowa Office	Colorado Office
Membership	$ 1,600.00	$ 3,743.84
Conference Surplus	407.08	
Sale of Proceedings	70.00	57.00
Interest	95.83	253.67
Beef Carcass Data Service	9.10	
Telephone Refund	34.70	
Sale of Filing Cabinet	126.54	
IRS Refund		19.92
Transfer of Funds		9,915.23
Total Income	$ 2,343.25	$13,989.66

Itemized Expenses

	Iowa Office	Colorado Office
Travel	$ 775.05	
Secretarial	700.22	
Conferences	106.18	
Office Supplies	18.16	$ 9.84
Phone	162.63	
Legal Services	39.72	
Carcass Data Service	18.20	
Printing	344.19	641.94
Postage	159.66	27.99
Copies	43.53	18.79
Conference Plaques	372.55	
IRS	158.53	
Discount - Canadian	13.13	
Transfer of Funds	9,915.23	
Board Expenses		195.34
Total Expenses	$12,826.98	$ 893.90

MINUTES OF BOARD OF DIRECTORS

BEEF IMPROVEMENT FEDERATION

The Lincoln Hilton

Lincoln, Nebraska

May 22, 1979

The meeting was called to order by President James Bennett at 7:00 a.m.. Present were Martin, Spader, Butts, Berg, Ludwig, Farmer, Scarth, Keffeler, Nelson, Shaw, Bennett, Linton, Gosey, Eller, Hubbard, Cundiff, Schroeder, Winn, Peterson and Jorgensen.

New Directors

Bennett introduced the newly elected members of the Board. They were:

Gene Schroeder, Central BCIA, Nebraska
Roger Winn, Eastern BCIA, Virginia
Earl Peterson, American Simmental Association
Sherm Berg, re-elected, American Shorthorn Association

Annual Meeting

Mark Keffeler invited the group to hold an annual meeting in South Dakota in the near future. Craig Ludwig explained to the group that the American Hereford Association will be holding a Sire Evaluation Conference in Denver in May, 1980, and suggested that BIF might wish to coordinate its meeting with this event. After much discussion, Eller moved and Keffeler seconded that BIF hold its annual convention in Denver in 1980, in Columbus, Ohio, in 1981, and in South Sakota in 1982. Motion carried.

The following committee was appointed to work on the 1980 convention: Craig Ludwig, chairman, Art Linton, Greg Martin, Gene Schroeder and Larry Cundiff. The dates indicated were in early May.

Feeder Cattle Grades

Dick Spader moved, Craig Ludwig seconded, that BIF endorse the proposed feeder calf grades as outlined in the Federal Register. Motion carried.

Mark Keffeler and Martin Jorgensen reported on the direct marketing project involving Wyoming, South Dakota and Iowa. This project is intended to help producers obtain full value for the cattle they produce.

The meeting was recessed until that evening.

Respectfully submitted,

Art Linton

Art Linton
Executive Director

MINUTES OF BOARD OF DIRECTORS

BEEF IMPROVEMENT FEDERATION

The Lincoln Hilton

Lincoln, Nebraska

May 22, 1979

The meeting was called to order by President James Bennett at 5:30 p.m.. Present were Martin, Spader, Butts, Berg, Ludwig, Farmer, Scarth, Keffeler, Nelson, Shaw, Bennett, Linton, Gosey, Eller, Hubbard, Cundiff, Schroeder, Winn and Peterson. Merlyn Nielsen was also present representing the reproduction committee.

Election of Officers

Greg Martin reported that the nominating committee submitted the name of Mark Keffeler as their candidate for president. Glenn Butts moved, Roger Winn seconded, that the nominations cease and the Executive Director be instructed to cast a unanimous ballot. Motion carried. The committee's nominee for vice president was Jack Farmer. Craig Ludwig moved, Tom Shaw seconded, that Jack be elected by unanimous acclamation. Motion carried.

Mid-Year Meeting

The group decided to hold the mid-year Board of Directors meeting in Kansas City on October 8-9, 1979.

Committee Reports

Reproduction

Merlyn Nielsen, secretary, presented the report of this committee which included a recommended formula for calculating calving interval. Considerable discussion followed about the merit of this formula. The principal question involved was whether to use a complex formula that would be very precise or a simpler formula that would be easily understood. Craig Ludwig moved, Roger Winn seconded, that the following simplified formula be adopted along with a statement relative to its limitations.

$$\text{Calving Interval} = \frac{[\text{Age at 1st calving} - \text{Age at last calving} + 365]}{\text{Number of calvings}}$$

Motion carried.

Greg Martin moved, Bob Scarth seconded, that first calving be expressed as a deviation of the weaning contemporary group. After considerable discussion the motion was withdrawn. Greg Martin moved, Bob Scarth seconded, that first calving be expressed as a simple age in months. Motion carried. Don Nelson moved, Jack Farmer seconded, that gestation length be reported whenever possible. Motion carried.

Reports of other committees will be forthcoming and will be acted upon at the mid-year board meeting.

Meeting was adjourned at 9:00 p.m..

Respectfully submitted,

Art Linton

Art Linton
Executive Director

BIF AWARDS PROGRAM

The Commercial Producer Honor Roll of Excellence

Chan Cooper	MT	1972
Alfred B. Cobb, Jr.	MT	1972
Lyle Eivens	IA	1972
Broadbent Brothers	KY	1972
Jess Kilgore	MT	1972
Clifford Ouse	MN	1973
Pat Wilson	FL	1973
John Glaus	SD	1973
Sig Peterson	ND	1973
Max Kiner	WA	1973
Donald Schott	MT	1973
Stephen Garst	IA	1973
J. K. Sexton	CA	1973
Elmer Maddox	OK	1973
Marshall McGregor	MO	1974
Lloyd Nygard	ND	1974
Dave Matti	MT	1974
Eldon Wiese	MN	1974
Lloyd DeBruycker	MT	1974
Gene Rambo	CA	1974
Jim Wolf	NE	1974
Henry Gardiner	KS	1974
Johnson Brothers	SD	1974
John Blankers	MN	1975
Paul Burdett	MT	1975
Oscar Burroughs	CA	1975
John R. Dahl	ND	1975
Eugene Duckworth	MO	1975
Gene Gates	KS	1975
V. A. Hills	KS	1975
Robert D. Keefer	MT	1975
Kenneth E. Leistritz	NE	1975
Ron Baker	OR	1976
Dick Boyle	ID	1976
James D. Hackworth	MO	1976
John Hilgendorf	MN	1976
Kahua Ranch	HI	1976
Milton Mallery	CA	1976
Robert Rawson	IA	1976
Wm. A. Stegner	ND	1976
U.S. Range Experiment Station	MT	1976
John Blankers	MN	1977
Maynard Crees	KS	1977
Ray Franz	MT	1977
Forrest H. Ireland	SD	1977
John A. Jameson	IL	1977
Leo Knoblauch	MN	1977
Milton Mallery	CA	1977
Jack Pierce	ID	1977
Mary & Stephen Garst	IA	1977

Odd Osteroos	ND	1978
Charles M. Jarecki	MT	1978
Jimmy G. McDonnal	NC	1978
Victor Arnaud	MO	1978
Ron & Malcolm McGregor	IA	1978
Otto Uhrig	NE	1978
Arnold Wyffels	MN	1978
Bert Hawkins	OR	1978
Mose Tucker	AL	1978
Dean Haddock	KS	1978

1979

Myron Hoeckle	ND	1979
Harold and Wesley Arnold		
Ralph Neill	IA	1979
Morris Kuschel	MN	1979
Bert Hawkins	OR	1979
Dick Coon	WA	1979
Jerry Northcutt	MO	1979
Steve McDonnell	MT	1979
Doug Vandermyde	IL	1979
Norman, Denton and Calvin Thompson	SD	1979

The Seedstock Breeder Honor Roll of Excellence

John Crowe	CA	1972
Dale H. Davis	MT	1972
Elliot Humphrey	AZ	1972
Jerry Moore	OH	1972
James D. Bennett	VA	1972
Harold A. Demorest	OH	1972
Marshall A. Mohler	IN	1972
Billy L. Easley	KY	1972
Messersmith Herefords	NE	1973
Robert Miller	MN	1973
James D. Hemmingsen	IA	1973
Clyde Barks	ND	1973
C. Scott Holden	MT	1973
William F. Borror	CA	1973
Raymond Meyer	SD	1973
Heathman Herefords	WA	1973
Albert West, III	TX	1973
Mrs. R. W. Jones, Jr.	GA	1973
Carlton Corbin	OK	1973
Wilfred Dugan	MO	1974
Bert Sackman	ND	1974
Dover Sindelar	MT	1974
Jorgensen Brothers	SD	1974
J. David Nichols	IA	1974
Bobby Lawrence	GA	1974

Marvin Bohmont	NE	1974
Charles Descheemaeker	MT	1974
Bert Crane	CA	1974
Burwell M. Bates	OK	1974
Maurice Mitchell	MN	1974
Robert Arbuthnot	KS	1975
Glenn Burrows	NM	1975
Louis Chesnut	WA	1975
George Chiga	OK	1975
Howard Collins	MO	1975
Jack Cooper	MT	1975
Joseph P. Dittmer	IA	1975
Dale Engler	KS	1975
Leslie J. Holden	MT	1975
Robert D. Keefer	MT	1975
Frank Kubik, Jr.	ND	1975
Licking Angus Ranch	NE	1975
Walter S. Markham	CA	1975
Gerhard Mitteness	KS	1976
Ancel Armstrong	VA	1976
Jackie Davis	CA	1976
Sam Friend	MO	1976
Healy Brothers	OK	1976
Stand Lund	MT	1976
Jay Pearson	ID	1976
L. Dale Porter	IA	1976
Robert Sallstrom	MN	1976
M. D. Shepherd	ND	1976
Lowellyn Tewksbury	ND	1976
Harold Anderson	SD	1977
WM. Borror	CA	1977
Rob Brown, Simmental	TX	1977
Glenn Burrows, PRI	NM	1977
Henry & Jeanette Chitty	FL	1977
Tom Dashiell, Hereford	WA	1977
Lloyd De Bruycker, Charolais	MT	1977
Wayne Eshelman	WA	1977
Hubert R. Freise	ND	1977
Floyd Hawkins	MO	1977
Marshall A. Mohler, Red Poll	IN	1977
Clair Percel	KS	1977
Frank Ramackers, Jr.	NE	1977
Loren Schlipf	IL	1977
Tom and Mary Shaw	ID	1977
Bob Sitz	MT	1977
Bill Wolfe	OR	1977
James Volz	MN	1977
A. L. Grau		1978
George Becker	ND	1978
Jack Delaney	MN	1978
L. C. Chestnut	WA	1978
James D. Bennett	VA	1978
Healey Brothers	OK	1978
Frank Harpster	MO	1978

Bill Womack, Jr.	AL	1978
Larry Berg	IA	1978
Buddy Cobb	MT	1978
Bill Wolfe	OR	1978

1979

Roy Hunt	PA	1979
Del Krumwiede	ND	1979
Jim Wolf	NE	1979
Rex and Joann James	IA	1979
Leo Schuster Family	MN	1979
Bill Wolfe	OR	1979
Jack Ragsdale	KY	1979
Floyd Mette	MO	1979
Glenn and David Gibb	IL	1979
Peg Allen	MT	1979
Frank and Jim Willson	SD	1979

Continuing Service Awards

Clarence Burch	Oklahoma	1972
F. R. Carpenter	Colorado	1973
E. J. Warwick	ARS-USDA, WA DC	1973
Robert de Baca	IA State University	1973
Frank H. Baker	OK State University	1974
D. D. Bennett	Oregon	1974
Richard Willham	IA State University	1974
Larry V. Cundiff	U.S. Meat Animal Research Center	1975
Dixon D. Hubbard	USDA-FES, WA DC	1975
J. David Nichols	Iowa	1975
A. L. Eller, Jr.	VPI & SU	1976
Ray Meyer	South Dakota	1976
Don Vaniman	Montana	1977
Lloyd Schmitt	Montana	1977
Martin Jorgensen	South Dakota	1978
James S. Brinks	Colorado State Univ.	1978
Paul D. Miller	Am. Breeding Svc-WI	1978

1979

C. K. Allen	Am. Angus Assn.	1979
William Durfey	NAAB	1979

Commercial Producer of the Year

Chan Cooper	MT	1972
Pat Wilson	FL	1973
Lloyd Nygard	ND	1974
Gene Gates	KS	1975
Ron Baker	OR	1976
Steve and Mary Garst	IA	1977
Mose Tucker	AL	1978

1979

Bert Hawkins	OR	1979

Seedstock Breeders of the Year

John Crowe	CA	1972
Mrs. R. W. Jones	GA	1973
Carlton Corbin	OK	1974
Leslie J. Holden	MT	1975
Jack Cooper	MT	1975
Jorgensen Brothers	SD	1976
Glenn Burrows	NM	1977
James D. Bennett	VA	1978

1979

Jim Wolf	NE	1979

Organizations of the Year

Beef Improvement Committee, Oregon Cattlemen's Assn.	1972
South Dakota Livestock Production Records Assn.	1973
American Simmental Association, Inc.	1974
American Simmental Association, Inc. (Breed)	1975
Iowa Beef Improvement Association (BCIA)	1975
The American Angus Association (Breed)	1976
The North Dakota Beef Cattle Improvement Assn.(BCIA)	1976
The American Angus ASsociation (Breed)	1977
The Iowa Beef Improvement Association (BCIA)	1977
The American Hereford Association (Breed)	1978
Beef Performance Committee OR Cattlemen's Assn.	1978

1979

The Iowa Beef Improvement Association (BCIA)	1979

Pioneer Awards

Jay L. Lush	Iowa State University	Research	1973
John H. Knox	New Mexico State University	Research	1973
Ray Woodward	American Breeders Service	Research	1974
Fred Willson	Montana State University	Research	1974
Charles E. Bell, Jr.	USDA-FES	Education	1974
Reuben Albaugh	University of California	Education	1974
Paul Pattengale	Colorado State University	Education	1974
Glenn Butts	Performance Registry Int'l.	Service	1975
Keith Gregory	US Meat Animal Research Cntr.	Research	1975
Bradford Knapp, Jr.	USDA	Research	1975
Forrest Bassford	Western Livestock Journal	Journalism	1976
Doyle Chambers	Louisiana State University	Research	1976
Mrs. Waldo Emerson Forbes	Wyoming Breeder	Breeder	1976
C. Curtiss Mast	Virginia BCIA	Education	1976
Dr. H. H. Stonaker	Colorado State University	Research	1976
Ralph Bogart	Oregon State University	Research	1977
Henry Holzman	South Dakota State University	Education	1977
Marvin Koger	University of Florida	Research	1977
John Lasley	University of Missouri	Research	1977
W. C. McCormick	Tifton, Georgia-Test Station	Research	1977
Paul Orcutt	Montana Beef Performance Assn.	Education	1977
J. P. Smith	Performance Registry Int'l.	Education	1977
James B. Lingle	Wye Plantation	Breeder	1978
R. Henry Mathiessen	Virginia Breeder-Still House Hollow	Breeder	1978
Bob Priode	VPI & SU	Research	1978

1979

Robert Koch	US Meat Animal Research Cntr.	Research	1979
Mr.&Mrs. Carl Roubicek	University of Arizona	Research	1979
Joseph J. Urick	U.S. Range Livestock Experiment Station	Research	1979

1979 COMMERCIAL PRODUCER OF THE YEAR

Bert Hawkins of Ontario, Oregon, was named BIF Commercial Producer of the Year.

Bert and his wife, Helen, started in the cattle business in 1947. Beginning with 200 first-calf heifers, the Hawkins' Malheur County ranch now carries nearly 1,000 head of brood cows. The average weaning weight of his calves is 476 pounds, up 127 pounds from when he began using performance tested bulls in 1950.

Bert recently finished his second term as President of the Oregon Cattleman's Association. He has served as 1st Vice President of the United States Animal Health Association. He also served as Chairman of the American National Cattlemen's Association Animal Health Committee. His interest in animal health began several years ago when he could see that performance was impaired if an animal had health problems. He soon realized the necessity of disease control, because of the relationship of the industry and human health.

Hawkins is a past President of the Malheur County Livestock Association, has served five years on the Board of Equalization, four years on the County Budget Committee, and six years on the Board of Review. He served on the Oregon State University Review Committee to examine effectiveness of statewide Extension programs. He was Grassman of the Year in 1955. Bert Hawkins is truly a dedicated leader in the cattle industry of Oregon and the United States.

1979 SEEDSTOCK PRODUCER OF THE YEAR

Jim Wolf was named BIF Seedstock Producer of the Year. Wolf has been involved in the operation of Wagonhammer Ranches since 1941. A family operation begun by his father, Julius, and uncle Max, who immigrated from Germany in 1896 and became vitally involved in buying, selling and feeding of cattle and importation of pedigreed draft horse. Wolf runs about 1,000 head of Angus and Angus-cross spring calving cows on 35,000 acres of Sandhills meadows located in Wheeler County.

The Commercial herd was started in 1959 and the registered Angus herd in 1965. In addition, Wolf maintains a small herd of high percentage and registered Charolais.

In 1977, Wagonhammer produced one of the top bulls in the American Angus Association's National Sire Evaluation Program, WAR Rito 3030, recently leased to the American Breeders Service at DeForest, Wisconsin.

Wagonhammer employs what is considered by many the most progressive techniques available, including artificial insemination, performance selection, pregnancy testing, semen evaluation and constant culling to improve productivity of the herd.

Nominated for the award by the American Angus Association, Wolf has been active in the Angus Herd Improvement Records Program for 13 years and has entered several bulls for National Angus Sire Evaluation.

Active in numerous beef industry organizations, he is president of Ideal Beef Systems, a director of Better Beef, Inc., and a member of BIF's advisory board of the Direct Marketing Project. A former 6 year director of BIF and chairman of its Carcass Committee, he also is chairman of U.S. Sen. Edward Zorinsky's advisory committee on agricultural policy and a member of the University of Nebraska Beef Industry Task Force Livestock Development Committee.

1979 CONTINUING SERVICE AWARDS

Dr. C. K. Allen is executive vice-president of the American Angus Association. In that capacity he has worked tirelessly to encourage the application of the principals espoused by BIF within the Angus breed. Prior to assuming his leadership position in the Angus breed he was director of education and research for the American Polled Hereford Association. In that position he directed their guidelines program and was instrumental in initiating their national sire evaluation program. C. K. served two terms as a director of BIF. It is for this leadership and support that BIF recognizes C.K. with a Continuing Service Award.

William Durfey, Columbia, Missouri, has been an active supporter and board member of BIF for many years. As director of breed improvement for the American-International Charolais Association he was instrumental in the writing and promotion of the Charolais herd improvement program. More recently he has been executive vice-president of the National Association of Animal Breeders. Bill has provided a valuable communication channel between BIF and the AI industry, actively encouraging those in that business to follow BIF guidelines. BIF is proud to recognize Bill with a Continuing Service Award.

1979 PIONEER AWARDS

Pioneer Awards were presented to honor an Institute of Agriculture and Natural Resources animal scientist, a native of Nebraska couple and a Montana cattleman for their role in the development of the beef performance movement.

Dr. Robert Koch, University of Nebraska-Lincoln animal scientist, is presently located at the Roman L. Hruska U.S. Meat Animal Research Center, Clay Center. He was chairman of the UNL animal science department from 1959 to 1966. Koch's early research on genetic and environmental relationships among economic traits of beef cattle contributed to the development of Record of Performance procedures. He also has worked with heterosis and a germ plasm evaluation project.

Koch was recognized for his outstanding teaching ability in the area of animal breeding while serving on the resident faculty of the University of Nebraska, where he also served for a time as head of the Animal Science Department. In 1976 he received the Animal Breeding and Genetics Award of the American Society of Animal Science. Even though Bob is being recognized as a pioneer he continues to make contributions to the knowledge of beef cattle genetics as a research geneticist at the U.S. Meat Animal Research Center, Clay Center, Nebraska.

Mr. and Mrs. Carl Roubicek, former Nebraskans now from Tucson, Arizona, were honored for Roubicek's involvement in determining proper procedure for performance testing, developing inbred lines, comparing large- and small-type cattle and confronting the dwarfism problem as Western Regional Coordinator for the W-1 Beef Cattle Breeding Project. Since 1955, he has helped develop a cooperative beef cattle breeding project with the San Carlos Apache Indian Tribe.

Joseph J. Urick, Miles City, Montana, was assistant animal husbandman at the North Montana Branch Experiment Station, Havre, Montana, where he tested the effectiveness of selection procedures to improve beef cattle production. He was instrumental in developing the Montana Beef Performance Association, of which he was a charter member. Urick also worked with inbreeding and heterosis.

Joe continues to create good will for the principals of performance testing through his work at the U.S. Range Livestock Experiment Station in Miles City, Montana.

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