Direct and Correlated Responses to Selection for Increased Weaning and Yearling Weights in Hereford Cattle I. Measurement of Selection Applied

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Story in Brief

The objective of this portion of the study was to quantify selection pressure in two lines of Hereford cattle selected for weaning weight (WWL) and yearling weight (YWL) over a 15-year period from 1964 to 1978. An Angus control line (CL) was also maintained to monitor environmental fluctuations. The primary data were collected on 1273 Hereford calves and 723 Angus calves. Each line consisted of 50 cows with two bulls and 10 heifers being selected each year. Selection was for heaviest weaning weight (WW) in the WWL, and heaviest yearling weight (YW) at 365 days for bulls and 425 days for heifers in the YWL. Over the 15-year period, 3.22 generations of selection had been practiced in the WWL and YWL. Cumulative selection differentials (CSD), a measure of applied selection pressure, in 1978 were 161 lb ($3.42\sigma_p$ pheontypic standard deviation) for WW in the WWL and 279 lb ($3.61\sigma_p$) for YW in the YWL. Rates of accumulation for these CSDs were 12.11 ± .53 lb/year and 21.42 ± .70 lb/year, respectively. Correlated CSDs for YW in the WWL and WW in YWL were 75 percent and 87 percent, respectively, as effective as direct selection. Selected bulls accounted for 74 percent and 83 percent of the selection pressure for WW in the WWL and YW in the YWL, respectively. The proportion of potential selection pressure achieved for WW in the WWL were 88 percent for sires and 70 percent for dams while the corresponding values in the YWL for YW were 100 percent and 43 percent.

Introduction

Improvement of the genetic composition of a cattle herd can essentially be achieved only through selection of individuals genetically superior for economically important traits. Most producers today put considerable emphasis on growth rate of cattle. We need fast growing, efficient cattle from birth to slaughter — cattle that will produce heavy weaning weights for cow calf producers; efficient gains for stocker operators and feedlots; heavy, lean, high yielding carcasses for packers; and tasty, tender products for the consumer.

Many selection studies have been conducted with laboratory species that demonstrate selecting for increased growth rate can be effective, but very few experiments have been designed to evaluate selection for growth rate in livestock species, especially cattle. Information is needed to demonstrate how rapid improvement can be made in certain traits along with an evaluation of how this selection also affects other economically important traits.

This study was started in the early sixties, but this article will focus on only one objective of the study: to quantify selection pressure achieved in a long-term study involving selection for growth in beef cattle.

Materials and Methods

Data used in this study were collected from 1964 to 1979 as part of the beef cattle breeding project at the Oklahoma Agricultural Experiment Station. Performance records of 1273 purebred Hereford calves, 239 selected Hereford cows and 57 selected Hereford bulls were analyzed. In addition, records of 723 purebred Angus calves, 126 Angus cows and 31 Angus bulls were also analyzed from an unselected control line (CL). Ideally, a control line has no selection pressure put on it for any trait, so the only fluctuations in average animal performance should be due to the management, environment or other nongenetic year-to-year variation. Comparisons between the selection lines and control line should give accurate measures of genetic trends realized by selection.

Foundation animals for the herd were assembled in 1960, and Hereford cows were randomly alloted to one of the two lines: (1) increased weaning weight line (WWL) and (2) increased yearling weight line (YWL). All lines were closed by 1967. An animal was considered "selected" if it produced at least one offspring in the selection line. Each year two bulls were selected from each line based upon the respective selection criteria, used for two years, then discarded. Thirteen top ranking heifers were retained from WWL and YWL each year and bred as yearlings. The 10 highest ranking pregnant heifers were selected to replace cows culled in each line. Fifty breeding age females were maintained per line.

Prior to 1969 the Angus line had been a progeny test line with selection based on increasing yearling weight. The decision was made in 1969 to convert this line to an unselected control line to monitor yearly environmental fluctuations. Up to this time only two calf crops had been sired by progeny tested bulls, so very little selection had actually occurred.

All lines were managed as a single herd except during breeding season, and every effort was made to insure as uniform an environment as possible for all cattle. Calves were born from early February through April of each year, and actual calf weights were recorded within 24 hours of birth. Calves were maintained with their dams on native and bermuda grass pastures without creep feed until weaning at an average age of 205 days. Following a 2-week warm up period after weaning, all bull calves were put on full feed for a 140-day gain test. Heifers were grazed out on wheat pasture, supplemented with prairie hay, alfalfa and concentrate to gain from .75 to 1.00 lb/day, and long yearling weights were taken at an average age of 425 days.

Complete performance records were collected on each calf through 365 days or 425 days for bulls and heifers, respectively. The following trait records were used in this study; birth weight (BW), preweaning average daily gain (WADG), weaning weight (WW), weaning grade (WG), weaning condition score (WC), postweaning average daily gain (YADG), yearling weight (YW), yearling grade (YG) and yearling condition score (YC).

Results and Discussion

Generations of selection

The first selections were made in 1964, and over the following 15-year period both WWL and YWL had undergone 3.22 generations of selection, while the CL

was similiar, involving 3.21 generations by the time the 1978 calf crop was produced. Interpretation of selection intensity and response to selection was easier since all lines were at the same state of selection. The generations of selection also point out that due to the long generation interval in cattle, it takes many years to substantially increase the frequencies of beneficial genes in a cattle herd through selection.

Cumulative selection applied

The average cumulative selection differential (CSD) for a trait measures the total amount of selection pressure applied since the beginning of the selection program in producing calves born in a given year. The total average cumulative selection differentials for each trait realized by the 1978 calf crop are given in Tables 1 and 2 for the WWL and YWL, respectively. These are presented as

Table 1. Cumulative selection differentials for sires (ΔS), dams (ΔD) and parent average (ΔM) in WWL

Trait	Type of CSD	Average cumulative selection differential (1978) Lb	Standard measure σ_p	Regression on year
Birth weight (lb)	ΔS	17.96	2.13	
	ΔD	10.14	1.17	
	ΔM	14.05	1.65	1.04 ± .08
Preweaning ADG (lb/day)	ΔS	.93	4.23	
	ΔD	.50	2.44	
	ΔM	.72	3.35	.05 ± .00
Weaning weight (lb)	ΔS	209.22	4.32	
	ΔD	113.63	2.51	
	ΔM	161.42	3.42	12.11 ± .53
Weaning grade[a]	ΔS	2.60	3.07	
	ΔD	1.35	1.68	
	ΔM	1.98	2.38	.15 ± .01
Weaning condition[b]	ΔS	1.53	2.01	
	ΔD	1.26	1.68	
	ΔM	1.39	1.85	.11 ± .00
Yearling weight (lb)	ΔS	250.47	3.28	
	ΔD	146.00	2.12	
	ΔM	198.19	2.71	15.94 ± .84
Postweaning ADG (lb/day)	ΔS	.27	.74	
	ΔD	.24	.77	
	ΔM	.26	.76	.03 ± .00
Yearling grade[a]	ΔS	2.30	3.10	
	ΔD	2.04	1.81	
	ΔM	2.17	2.46	.18 ± .02
Yearling condition[b]	ΔS	.80	1.28	
	ΔD	.84	1.37	
	ΔM	.82	1.33	.07 ± .01

[a]17-point scoring system where 13 = average choice, 14 = high choice, etc.
[b]17-point scoring system where 13 = average fat cover.

amount due to sires (ΔS), amount due to dams (ΔD) and parent average (ΔM). Also, the CSDs are reported in standard measure so comparisons can be made between various traits in amount of selection pressure realized even though the actual trait measurements are in various units (i.e., lb vs lb/day). In addition, ΔM was regressed on years to give an estimate of the average yearly selection pressure on each trait during the 15-year period.

Selection for WW in WWL and YW in YWL progressed at fairly regular rates throughout the study. In 1978, ΔM was 161 lb ($3.42\sigma_p$-phenotypic standard deviations) for WW in the WWL and had accumulated at a rate of 12.11 ± .53 lb per year, while corresponding values for YW in the YWL were 279 lb ($3.61\sigma_p$) and 21.42 ± .53 lb per year, while corresponding values for YW in the YWL were 279 lb ($3.61\sigma_p$) and 21.42 ± .70 lb per year. These CSDs occurred during 3.22

Table 2. Cumulative selection differentials for sires (ΔS), dams (ΔD) and parent averages (ΔM) in YWL

Trait	Type of CSD	Average cumulative selection differential (1978)		Regression on year
		Lb	Standard measure σ_p	
Birth weight (lb)	ΔS	21.80	2.52	
	ΔD	10.48	1.23	
	ΔM	16.14	1.88	1.07 ± .07
Preweaning ADG (lb/day)	ΔS	.80	3.54	
	ΔD	.44	2.07	
	ΔM	.62	2.81	.05 ± .00
Weaning weight (lb)	ΔS	185.02	3.76	
	ΔD	101.78	2.20	
	ΔM	143.40	2.98	10.76 ± .47
Weaning grade[a]	ΔS	2.30	2.74	
	ΔD	1.18	1.45	
	ΔM	1.74	2.09	.13 ± .01
Weaning condition[b]	ΔS	1.37	1.87	
	ΔD	.82	1.10	
	ΔM	1.10	1.49	.07 ± .00
Yearling weight (lb)	ΔS	362.84	4.59	
	ΔD	194.98	2.63	
	ΔM	278.91	3.61	21.42 ± .70
Postweaning ADG (lb/day)	ΔS	1.19	3.47	
	ΔD	.59	1.89	
	ΔM	.89	2.68	.07 ± .00
Yearling grade[a]	ΔS	1.27	3.03	
	ΔD	1.79	1.54	
	ΔM	1.60	2.29	.12 ± .01
Yearling condition[b]	ΔS	1.60	2.53	
	ΔD	1.14	1.64	
	ΔM	1.37	2.08	.11 ± .01

[a]17-point scoring system where 13 = average choice, 14 = high choice, etc.
[b]17-point scoring system where 13 = average fat cover.

generations of selection, which means that selection pressure occurred at the rate of 1.06 and $1.12\sigma_p$ per generation for WW and YW, respectively.

Although selection was for WW in the WWL and YW in the YWL, other correlated traits also experienced selection pressure because genes that affect WW also affect other traits. Correlated CSDs in the WWL were 14 lb, .72 lb/day, 198 lb, .26 lb/day, 1.98 units, 1.39 units, 2.17 units and .82 units for BW, WADG, YW, YADG, WG, WC, YG and YC, respectively. Comparisons of the various traits in standard measure CSDs indicate most selection pressure occurred on WW in the WWL followed by WADG. It is of primary interest to evaluate the correlated CSD for YW in the WWL because if appreciable selection can be applied for YW by selecting for WW, considerable savings in time and money can be realized by selecting animals at weaning instead of waiting until calves are a year of age. YW underwent $2.71\sigma_p$ of selection pressure in the WWL or 75 percent as much pressure as direct selection for YW in the YWL. This suggests that animals selected for heaviest WW are also above average for YW.

In the YWL, correlated CSDs were 161 lb, .62 lb/day, 143 lb, .89 lb/day, 1.74 units, 1.10 units, 1.79 units and 1.37 units for BW, WADG, WW, WG, WC, YG and YC, respectively. Most selection pressure occurred for YW ($3.61\sigma_p$) with considerable correlated pressure in WW ($2.98\sigma_p$); therefore, selecting for YW alone will also tend to increase WW. Since WW and YW are both traits that are influenced by numerous components, it is important to evaluate correlated selection intensity. BW is of specific concern since heavy BWs have been associated with calving difficulty. CSD for BW in both lines was positive, increasing 1.06 lb/year or approximately accumulating at 50 percent of the selection pressure exerted on primary selection traits for each line.

Concern has also been expressed by some in the industry that selection for performance will result in the deterioration of conformation unless conformation is included in the selection program. Another concern is that selection for increased weight will increase fatness of animals at a given age. Weaning conformation (WG) and yearling conformation (YG) both showed considerable positive selection pressure in both lines. Correlated emphasis on fatness, although positive, was much smaller.

Table 3 presents CDSs for the control line. CSDs accumulated in a sporadic manner for most traits with most of it occurring in the first few years prior to the conversion of the line to a control line. Although positive CSDs were realized for all traits, they were generally small with only 13.0 lb ($.36\sigma_p$) and 42.1 lb ($.70\sigma_p$) CSD for WW and YW, respectively, in the 1978 calf crop.

Cumulated selection differentials are the result of sire and dam selection over the long term. In this experiment the proportion of the total selection pressure attributable to sires was 74 percent for WW in the WWL and 83 percent for YW in the YWL. Sire selection pressure is usually greater than dam selection because of the large proportion of heifers that must be saved for replacement. Replacement of females in the lines was somewhat faster than replacement rates in most commerical herds; thus, in most practical situations the relative contribution of bull selection to genetic improvement of the herd would be expected to be even larger than experienced in this study.

Maximum potential selection

The proportion of potential selection realized can be evaluated by comparing the actual vs potential selection differentials for the traits of primary selection in each line. Selection differentials per generation were calculated for the selected parents of calves born in the study and for the actual top bulls and heifers

available for selection in each line according to line criteria. In the WWL, 88 percent and 70 percent of potential selection was realized in WW for sires and dams, respectively, while corresponding values in the YWL for YW were 100 percent and 43 percent respectively. Selection criteria for bulls in the YWL was followed exactly; however, heifer selection in the YWL was quite a bit poorer than in the WWL. In heifers, failure to conceive was probably the largest reason for loss of selection pressure, with other unsoundnesses also contributing.

Table 3. Cumulative selection differentials for sires (ΔS), dams (ΔD) and parent averages (ΔM) in CL

Trait	Type of CSD	Average cumulative selection differential (1978)		Regression on year
		Lb	Standard measure σ_p	
Birth weight (lb)	ΔS	−.42	−.03	
	ΔD	1.57	.19	
	ΔM	.57	.08	.70 ± .06
Preweaning ADG (lb/day)	ΔS	.05	.30	
	ΔD	.07	.40	
	ΔM	.06	.35	.08 ± .03
Weaning weight (lb)	ΔS	10.08	.30	
	ΔD	15.91	.42	
	ΔM	12.99	.36	10.92 ± .72
Weaning grade[a]	ΔS	.29	.48	
	ΔD	.21	.34	
	ΔM	.25	.41	.10 ± .01
Weaning condition[b]	ΔS	.22	.25	
	ΔD	.14	.06	
	ΔM	.18	.16	.07 ± .01
Yearling weight (lb)	ΔS	36.81	.56	
	ΔD	47.29	.83	
	ΔM	42.50	.70	15.37 ± 1.28
Postweaning ADG (lb/day)	ΔS	.23	.99	
	ΔD	.22	.83	
	ΔM	.23	.93	.17 ± .15
Yearling grade[a]	ΔS	.42	.53	
	ΔD	.78	1.06	
	ΔM	.60	.80	.08 ± .01
Yearling conditon[b]	ΔS	.60	.29	
	ΔD	.29	.97	
	ΔM	.47	.63	.03 ± .01

[a]17-point scoring system where 13 = average choice, 14 = high choice, etc.
[b]17-point scoring system where 13 = average fat cover.