SELECTION FOR INCREASED WEANING OR YEARLING WEIGHT IN ANGUS CATTLE. I. MEASUREMENT OF SELECTION APPLIED

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Story in Brief

A long-term study was conducted to evaluate direct and correlated responses to selection for increased weaning or yearling weight. The objective of this portion of the study was to measure the amount of selection applied during 14 years of selection for growth traits in Angus cattle. Three fifty-cow, four-sire lines were selected from 1965-1979 for heaviest individual weaning weight, heaviest yearling weight or a combination of individual and progeny weaning weights, respectively. A fourth line, of similar size, was maintained as an unselected control line to monitor yearly environmental changes.

Over the 14-year period, 3.87 and 3.72 generations of selection occurred in the weaning and yearling weight lines, respectively. The progeny test line was terminated in 1978 and 2.68 generations of selection had occurred to that point. Mean cumulative selection differentials, which measure the amount of selection applied, in 1979 were 169 lb for weaning weight in the weaning weight line and 296 lb for yearling weight in the yearling weight line. Selection pressure accumulated at the rate of 12.3 and 21.4 lb/yr. for weaning and yearling weight respectively. Indirect selection for yearling weight in the weaning weight line and weaning weight in the yearling weight line were 72 and 70 percent, respectively, as effective as direct selection for weaning weight in the weaning weight line and yearling weight in the yearling weight line.

(Key Words: Beef Cattle, Selection Differential, Weaning Weight, Yearling Weight, Angus)

Introduction

Selection is one of the primary forces by which breeders can change the genetic composition of their herds. The increasing demand for faster growing, more efficient cattle has made selection for growth rate an important objective for the beef industry. While many selection experiments have demonstrated the effectiveness of selection for growth rate in poultry and laboratory animals, few such studies have been conducted with livestock species such as beef cattle. Therefore, a long-term study was initiated in 1960 at the Oklahoma Agricultural Experiment Station to evaluate direct and correlated responses to selection for increased weaning or yearling weight in beef cattle. The objective of this portion of the study was to measure the selection pressure applied during 14 years of selection for growth traits in Angus cattle.

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Materials and Methods

Three selection lines and an unselected control line were established from a common base of Angus cattle. Foundation cows, typical for the Angus breed, were obtained from several herds and randomly allotted to four 50-cow lines in 1963. Twenty-five foundation sires were used across lines from 1963 through 1966. First selections within the lines were made from the 1965 calf crop. Selection criteria for replacement breeding animals were heaviest individual 205-day weaning weight in the weaning weight line (WWL), heaviest individual 365-day (bulls) and 425-day (heifers) yearling weight in the yearling weight line (YWL) and a combination of heaviest individual and progeny 205-day weaning weights in the progeny test line (PTL).

The fourth line was maintained as an unselected control line (CL) and replacement breeding animals were chosen to have as near zero selection differentials for both weaning and yearling weight as possible. Originally, the CL was designed as a progeny test line for yearling weight; however, in 1969 it was converted to a control line to monitor yearly environmental changes. Since only two calf crops had been sired by progeny-tested bulls up to that point, very little selection had actually been practiced. Ideally, a control line has no selection pressure applied to any traits, thus the only fluctuations in average animal performance should be environmental or nongenetic in nature. Differences between select and control lines should represent genetic change resulting from selection.

Fifty breeding age females were maintained in each of the four lines. In order to maintain a 20 percent replacement rate, 10 cows were culled each year and replaced with the 10 highest ranking pregnant heifers based on line criteria. Initially, the 13 highest ranking heifers in each line (zero selection differentials for both weaning and yearling weight in the CL) were bred to selected bulls as yearlings. Of the 13 heifers exposed, the top 10 diagnosed pregnant following the breeding season were selected to remain in the line.

Each year two bulls were selected in the WWL, YWL and CL based on the respective line criteria. Bulls were first used as two year olds through the 1970 breeding season and as yearlings in subsequent years. As a result of this change in procedure, no bulls were selected from the 1969 calf crop. In the PTL five bulls were selected on the basis of individual weaning weight and mated to cows in an Angus test herd. Two bulls were subsequently selected on the basis of progeny weaning weight. Bulls were three years old when they were first mated to cows in the PTL. This procedure was followed in the PTL from 1966 through 1976; thereafter, two bulls were selected each year based on individual performance. Only the last two calf crops in this line were sired by bulls that had not been progeny tested. Selected bulls in all lines were used for two years. Thus, four bulls were used per year in each line, two being used for the first time and two being used for the second time. The total numbers of sires selected were 28, 26, 22 and 29 for the WWL, YWL, PTL and CL, respectively.

Cattle were maintained at the Southwestern Livestock and Forage Research Station at El Reno, OK. All lines were managed as a single herd except during the breeding season and every effort was made to ensure as uniform an environment as possible for all cattle. Calves were born from February through April each year. Within 24 hours after birth, all calves were tagged and tattooed for identification and birth weights were recorded. Calves were allowed to run with their dams on native range and bermudagrass pasture and received no creep feed. In

winter, cows had access to wheat pasture and milo stubble and were supplemented with prairie hay, alfalfa or cottonseed cake whenever necessary. Calves were weaned at an average age of 205 days. Following a two-week warm up period after weaning, bull calves were put on full feed for a 140-day gain test. Heifer calves were placed on wheat pasture and supplemented with prairie hay, alfalfa and concentrate to gain approximately .75 to 1.00 lb/day. Long yearling weights were determined on the heifers at an average age of 425 days.

Complete performance data were collected on all calves through 365 days for bulls and 425 days for heifers. Performance data through yearling age were collected on 694, 691, 666 and 698 calves in the WWL, YWL, PTL and CL, respectively. Traits evaluated were birth weight (BW), preweaning daily gain (WDG), weaning weight (WW), weaning conformation grade (WG), weaning condition score (WC), weaning to yearling daily gain (YDG), yearling weight (YW), yearling conformation grade (YG) and yearling condition score (YC). Weaning weights were adjusted to a 205-day basis and then adjusted for age of dam. Yearling weights (365-day for bulls and 425-day for heifers) were calculated by multiplying YDG by 160 for bulls and 220 for heifers and adding the 205-day age of dam adjusted WW.

Results and Discussion

Generations of Selection

The first selections were made from the 1965 calf crop and over the following 14-year period 3.87 and 3.72 generations of selection occurred in the WWL and YWL, respectively. Generation turnover in the CL was slightly slower with 3.40 generations of selection occurring by the time the 1979 calf crop was produced. The PTL was terminated with the 1978 calf crop and 2.68 generations of selection had occurred. Generation turnover in this line was slower because of the additional time required for the progeny test data to finalize selections.

Cumulative Selection Applied

The average cumulative selection differential (CSD) for a trait measures the total amount of selection that has accumulated through the parents of calves born in a given year. The average CSD's realized by the 1979 calf crop are presented in both actual and standard measure in Tables 1 and 2 for the WWL and YWL, respectively. Expressing CSD's in standard measure allows comparisons to be made among the various traits. Values are presented as the amount attributed to sires (S), the amount attributed to dams (D) and the parent average (M). Also, the parent average was regressed on year to give an estimate to the average yearly selection pressure for each trait during the 14-year period. Corresponding values for the CL are presented in Table 3.

Direct selection pressure accumulated at a fairly steady rate in both the WWL and YWL. In the WWL, selection pressure for WW accumulated at the rate of 12.3 lb/yr and for the average of parents producing calves in 1979, the total amount of selection pressure which had been applied since the beginning of the study was 169 lb (3.75 phenotypic standard deviations). Corresponding values for YW in the YWL were 21.4 lb/yr and 296 lb (3.87 phenotypic standard deviations). Expressed on a per generation basis, selection pressure accumulated at rates of .97 and 1.00 phenotypic standard deviations per generation for WW in the WWL and YW in the YWL (Table 4).

Table 1. Cumulative selection differentials for sires (S), dams (D) and parent average (M) in the weaning weight line.

Trait	Type	Average cumulative selection differential (1979) Actual Measure	Standard Measure[a]	Regression of Actual Measure on Year
Birth weight (lb)	S	12.2	1.5	
	D	13.3	1.7	
	M	12.8	1.6	.92 ± .10
Preweaning daily gain (lb/day)	S	.9	4.4	
	D	.6	3.1	
	M	.8	3.7	.05 ± .002
Weaning weight (lb)	S	203.9	4.4	
	D	133.7	3.1	
	M	168.8	3.8	12.26 ± .53
Weaning conformation grade[b]	S	1.5	2.2	
	D	1.1	1.7	
	M	1.3	1.9	.08 ± .01
Weaning condition score[c]	S	1.5	2.3	
	D	1.2	1.9	
	M	1.3	2.1	.09 ± .004
Weaning to yearling daily gain (lb/day)	S	.3	.8	
	D	.1	.4	
	M	.2	.6	.01 ± .003
Yearling weight (lb)	S	250.2	3.1	
	D	146.6	2.3	
	M	198.4	2.7	13.07 ± .66
Yearling conformation grade[b]	S	1.5	2.0	
	D	1.1	1.6	
	M	1.3	1.8	.09 ± .01
Yearling condition score[c]	S	.8	1.3	
	D	.5	.8	
	M	.7	1.0	.04 ± .004

[a]Standard measure is expressed in phenotypic standard deviation units.
[b]Conformation grade on a 17 point scale with 12=low choice, 13=average choice.
[c]Condition score on a 9 point scale with 1=thin to 9=very fat.

Although the primary selection criterion was either WW or YW, other traits also underwent some selection pressure as a result of genetic relationships among the traits. It is of particular interest to evaluate the correlated CSD's for YW in the WWL and WW in the YWL. If appreciable selection pressure can be applied for YW by selecting for WW then considerable time and money may be saved by selecting animals at weaning versus at a year of age. In the WWL, the average correlated CSD for YW was 198 lb (2.71 phenotypic standard deviations). This was 72 percent as effective as direct selection for YW in the YWL. Similarily, the selection pressure for WW in the YWL increased 70 percent (140 lb) as fast as direct selection for WW in the WWL.

Table 2. Cumulative selection differentials for sires (S), dams (D) and parent average (M) in the yearling weight line.

Trait	Type	Average cumulative selection differential (1979) Actual Measure	Standard Measure[a]	Regression of Actual Measure on Year
Birth weight (lb)	S	15.4	1.8	
	D	12.1	1.5	
	M	13.8	1.7	1.03 ± .08
Preweaning daily gain (lb/day)	S	.8	3.4	
	D	.4	2.3	
	M	.6	2.9	.04 ± .002
Weaning weight (lb)	S	173.7	3.5	
	D	106.7	2.4	
	M	140.2	3.0	9.28 ± .52
Weaning conformation grade[b]	S	1.8	2.2	
	D	1.0	1.2	
	M	1.4	1.7	.08 ± .01
Weaning condition score[c]	S	1.3	2.1	
	D	.5	.7	
	M	.9	1.4	.05 ± .01
Weaning to yearling daily gain (lb/day)	S	1.2	3.6	
	D	.9	2.8	
	M	1.1	3.2	.08 ± .003
Yearling weight (lb)	S	362.6	4.4	
	D	230.4	3.4	
	M	296.5	3.9	21.38 ± .87
Yearling conformation grade[b]	S	3.2	4.4	
	D	1.8	2.5	
	M	2.5	3.4	.17 ± .01
Yearling condition score[c]	S	1.3	2.1	
	D	.9	1.5	
	M	1.1	1.8	.08 ± .01

[a]Standard measure is expressed in phenotypic standard deviation units.
[b]Conformation grade on a 17 point scale with 12=low choice, 13=average choice.
[c]Condition score on a 9 point scale with 1=thin to 9=very fat.

Correlated CSD's for the remaining traits accumulated at slower rates. Unfortunately, selection pressure for BW increased at the rate of .92 lb/yr in the WWL and 1.03 lb/yr in the YWL. Conformation grades and condition scores also showed a slight increase in selection pressure. This is of particular interest because of industry concern that selection for growth traits might result in the deterioration of conformation unless conformation is included in the selection program.

As shown in Table 3, a slight amount of selection occurred in the CL. Average parent CSD's increased slightly each year for all traits except BW. This may be partly explained by the small amount of selection which occurred prior to the time this line was converted to an unselected control line.

Table 3. Cumulative selection differentials for sires (S), dams (D) and parent average (M) in the control line.

Trait	Type	Average cumulative selection differential (1979) Actual Measure	Standard Measure[a]	Regression of Actual Measure on Year
Birth weight (lb)	S	-.1	0.0	
	D	1.4	.2	
	M	.6	.1	-.01 ± .05
Preweaning daily gain (lb/day)	S	0.0	0.0	
	D	.1	.4	
	M	0.0	.2	.002 ± .001
Weaning weight (lb)	S	-3.1	0.0	
	D	14.7	.4	
	M	5.8	.2	.50 ± .17
Weaning conformation grade[b]	S	.2	.4	
	D	.2	.3	
	M	.2	.3	.02 ± .01
Weaning condition score[c]	S	.3	.4	
	D	.1	.1	
	M	.2	.2	.01 ± .004
Weaning to yearling daily gain (lb/day)	S	.3	1.1	
	D	.2	1.0	
	M	.3	1.1	.02 ± .003
Yearling weight (lb)	S	38.5	.6	
	D	48.2	.8	
	M	43.3	.7	2.73 ± .54
Yearling conformation grade[b]	S	.6	.8	
	D	.9	1.2	
	M	.7	1.0	.05 ± .01
Yearling condition score[c]	S	.3	.3	
	D	.7	1.1	
	M	.5	.7	.03 ± .01

[a]Standard measure is expressed in phenotypic standard deviation units.
[b]Conformation grade on a 17 point scale with 12=low choice, 13=average choice.
[c]Condition score on a 9 point scale with 1=thin to 9=very fat.

Selection differentials calculated this way would not be appropriate for measuring selection pressure in the PTL. Thus, CSD's are not presented for this line. The progeny test line is described as part of the overall design of this study in order that the genetic progress obtained in this line can be compared with that obtained in the other lines in the second article of this series on selection for increased weaning or yearling weight.

Actual versus Potential Selection

Selection differentials per generation were calculated for selected sires (S) and selected dams (D) by averaging the individual selection

Table 4. Actual and potential selection differentials for weaning weight and yearling weight per generation for selected sires (S), selected dams (D) and midparents (M), expressed in standard measure[a].

Line	Item	Trait			
		Weaning weight		Yearling weight	
		Actual	Potential	Actual	Potential
Weaning weight line	S	1.30	1.43	.81	.84
	D	.64	.79	.54	.61
	M	.97	1.11	.67	.73
Yearling weight line	S	1.12	1.15	1.52	1.51
	D	.37	.66	.49	.75
	M	.74	.91	1.00	1.13

[a]Standard measure is expressed in phenotypic standard deviation units.

differentials for sires and dams of all progeny excluding those from foundation parents. Potential selection differentials were calculated by averaging individual deviations of the bulls and heifers (two bulls and 10 heifers per line) with the largest values based on line criteria in each line each year. Comparing actual and potential selection differentials provides an estimate of the proportion of the possible selection that was actually applied toward the primary trait in each line. Although strict adherence to selection criteria was attempted throughout the study, some high ranking individuals may have been culled because of development of serious unsoundness, illness or death prior to their use in the selection line, or in heifers, reproductive failure during the first breeding season. Actual and potential selection differentials (in standard measure) for WW and YW are presented in Table 4 for the WWL and YWL.

In the WWL, the actual selection differentials per generation for WW were 91 and 81 percent of the potential for sires and dams, respectively. Corresponding values for YW in the YWL were 100 and 65 percent, respectively. In the YWL, top ranked bulls for YW sired progeny in all cases; however, the potential selection realized for dams was quite low. In both lines, the primary reason for loss of selection pressure in heifers was reproductive failure during the first breeding season.

Total selection pressure is a result of both sire and dam selection. The proportion of selection pressure attributable to selected sires versus selected dams was evaluated by comparing the relative magnitude of the parent average selection differential (M) due to sires (S) and dams (D). The proportion of selection pressure attributable to selected sires in this study was 67 percent for WW in the WWL and 76 percent for YW in the YWL. Generally, sire selection accounts for a greater proportion of the total selection pressure. The increased importance of dam selection in this study may have been a result of the fairly rapid replacement rate for females in these lines (10/50 cows per line per year).