Selection for Meat Tenderness in Angus Cattle

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It is possible to improve meat tenderness through direct selection based on the Warner-Bratzler Shear (WBSF) values of fed bulls. The level of heritability of WBSF values was in the moderate range, similar to that of growth traits. The procedure used in this study, however, would be difficult to adapt to the current industry methods of selection of beef bulls.

Summary

A study of direct response of divergent selection for meat tenderness using Warner-Bratzler Shear Force (WBSF) values of Angus bulls was conducted. Bulls generated from an Angus herd were selected for use in subsequent generations (years) based on their WBSF values. WBSF data from a total of 299 bulls born over an eight-year period were analyzed. Genetic trends were plotted as averages of estimated breeding values (EBV). Estimated breeding values are our best indication of how much of their genetic superiority (or inferiority) animals will pass their on to their progeny. The average WBSF values (7.8 vs 8.8 lb) and the EBV for WBSF (-0.55 vs 0.81 lb) of progeny of tender bulls across the years of the study were lower than those of tough bulls. The WBSF value phenotypic means decreased 0.71 lb and 0.66 lb per year, respectively, for the progeny of tender and tough bulls. The genetic values (EBV for WBSF) decreased 0.09 lb per year for the progeny of tender bulls and increased 0.07 lb per year for the progeny of tough bulls. The estimate of direct heritability from this selected population was moderate to high ($h^2 = 0.40 \pm 0.18$). Realized heritabilities obtained from the regression of selection response (WBSF) on cumulative selection differentials were 0.32 ± 0.27 and 0.21 ± 0.20 for progeny of tender and tough bulls, respectively. An unexpected result was that the phenotypic values for WBSF values declined in both the progeny of bulls selected as tough and those selected as tender. An explanation for the declining WBSF for progeny of tough bulls, instead of the expected increase might be due to short duration of selection, random environmental effects, low selection pressure, and sampling errors, since there were limited numbers of the bulls evaluated and it was not possible to collect freezable semen from all of the bulls prior to slaughter. It should be cautioned, however, that the selection of meat quality traits, tenderness or marbling, by whatever means (EPDs, molecular markers, or direct selection as in this study) may have unintended consequences such as losses in other traits such as growth rate, live or carcass weight, muscling (ribeye area) and even in maternal traits such as fertility and milk yield. Thus, it is important to consider all of the genetic information available on the bulls used in breeding programs in order to avoid losses in other traits that are important to the profitability of the beef enterprise.

Introduction

Tenderness is considered the most economically important trait determining consumer eating satisfaction (Savell et al., 1989; Morgan et al., 1991; Brooks et al., 2000). Tenderness can be improved by changing to breeds that are known to produce more tender beef as well as by selection for improved tenderness within breeds. The average heritability estimates for most carcass traits, including tenderness, vary within the moderate-to-high range indicating that selection for these traits should be effective. However, a study of selection for meat tenderness in beef cattle had not been conducted previously. Currently no means for increasing tenderness directly has been found to be feasible by the beef industry but the use of genomic

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(DNA testing) is being increasingly adapted. A study of selection for meat tenderness in beef cattle based on the use of direct selection for Warner-Bratzler Shear Force values (WBSF), however, had not been conducted.

Therefore, we began a study of selection for meat tenderness in Angus cattle evaluating whether direct selection for meat tenderness could be an effective tool to improve tenderness in beef cattle. The objective of this study was to examine the response to selection for meat tenderness, with specific objectives being: to examine phenotypic and genetic differences between the progeny of tough and tender bulls, to observe phenotypic (WBSF) and genetic (estimated breeding values for WBSF) changes over the years of study and to evaluate the factors influencing response to selection.

Procedure

The experiment was conducted at the University of Florida Santa Fe Beef and Beef Research Units, located north of Gainesville, Florida. This experiment was designed to examine the effect of a direct selection program for meat tenderness. The experiment began with grade Angus calves born in 1994. The bulls born in 1994 were sired by bulls available via AI in 1993. The bulls born in 1994 were semen-collected and slaughtered and then evaluated for WBSF evaluation. The bulls born with highest and lowest WBSF values were selected for use to inseminate Angus cows. The dams of these bulls included both purebred and grade Angus cows. Starting in 1996, the calves born in this study were sired by the bulls selected based on their WBSF breeding values. The first generation resulting from selection for lower and higher WBSF values was born in 1996 and established the two selected groups of progeny of bulls selected for tenderness and toughness. The type of selection utilized is referred to as divergent selection which is selection in both directions, for increased tenderness and increased toughness via WBSF evaluation. Selection decisions were based on phenotypic values (WBSF) within year. Selection pressure for meat tenderness was applied to the males only. The exception to this was that foundation cows that had produced a son evaluated as tender based on WBSF were assigned subsequently to be bred to “tender” bulls and cows that produced a “tough” son to “tough” bulls. Daughters of bulls selected as tough were assigned to be bred to tough bulls and daughters of tender bulls, to tender bulls. There was no direct evaluation of tenderness of the any females in the study as in order to evaluate animals for this trait it is necessary to slaughter them. Heifers were exposed for breeding first as yearlings and were culled primarily on fertility.

After the bull calves were expected to have reached puberty, at 13 to 14 mon of age, semen was collected and frozen. It was not possible to collect freezable semen on all bulls each year. The bulls were then slaughtered and their tenderness was determined using WBSF evaluation. After evaluation, the three or four of the bulls with the highest and also the lowest WBSF values were selected for use. The semen from selected bulls was used to inseminate purebred and grade Angus cows with about half the cowherd bred to tough and half to tender bulls. About 30-35 bulls from both progeny of bulls selected for tough and tender were evaluated annually from those born from 1994 through 2000.

Results

The estimate of heritability for WBSF determined using ASREML was moderate (h^2 = 0.40 ± 0.18) (Table 1). This estimate of heritability for direct effects was within the range of those reported from reviews in the literature (Marshall, 1994; Koots et al., 1994; Bertrand et al., 2001; Burrow et al., 2001). Most of reported estimates of heritability of WBSF have been based upon data from unselected populations of purebred or crossbred cattle. However, the estimate of heritability in the current study was based on this selected population.

The high estimate from the present study relative to literature estimates may be due in part to the fact that this estimate came from a selected population which can be quite different from those of unselected populations. However, the high estimate of direct heritability from the present study may also indicate that selection for meat tenderness in this manner might be effective.

The realized heritability resulting from regressing response to selection on cumulative differential for progeny of tender bulls was higher than that of tough bulls (0.32 vs 0.21). This value is somewhat lower than the overall heritability for the entire population (h^2=0.40 ± 0.18).

Phenotypic and Genetic Evaluations

The WBSF values of individual bulls ranged from 4.01 to 13.18 lb with a mean of 6.88 lb for the progeny of tender bulls and from 4.21 to 16.33 lb with a mean of 7.80 lb for the progeny of tough bulls. The WBSF values were affected by year effects. WBSF values were also affected by sire within selected group. There was no interaction between year of calf's birth and sire group indicating that year effects were independent from sire group effects. Year effects occurred in spite of the fact that the same machine, and for the most part, the same individuals, conducted the WBSF evaluations each year. Robinson et al. (2001) reported that fluctuation in WBSF values may reflect differences in handling pre- and post-slaughter procedures that can cause difficulties in measuring tenderness consistently.

The least squares means for both WBSF values (7.83 ± 0.26 vs 8.82 ± 0.29 lb) and the EBV for WBSF (-0.55 ± 0.11 vs 0.82 ± 0.11 lb) across all years were lower for the progeny of tender bulls than those of the tough bulls (Table 2). There was an approximately 41.17% improvement of the phenotypic means, respectively, resulting from selection after 7 years observation. These findings indicated that selection for tenderness can be effective.

The decline in response which occurred after year 5 was due perhaps to a decline in the of selected bulls were included as dams in each group in the later years should have increased the response. An explanation for the declining WBSF for progeny of tough bulls, instead of the expected increase might be due to the short duration of selection, random environmental effects, low selection pressure, sampling error and random genetic drift, since there were limited numbers of the bulls evaluated and it was not possible to collect freezable semen from all of the bulls prior to slaughter.

Genetic Trend

The EBV of WBSF began to diverge early in the experiment and continued to diverge at a steady rate. However, after yr 5 the divergence decreased gradually. The genetic trend of bulls selected for tenderness showed few genetic changes after yr 5. The regression coefficients of annual changes of WBSF-EBV on year of birth were of similar magnitude for progeny of both selected sire groups. The estimates of genetic trend in the progeny of both tough and tender bulls were not different from zero. However, these findings showed that the EBV of WBSF of progeny of tender sire tended to decrease 0.084 lb per year and those of tough sire tended to increase 0.073 lb/yr. The declining EBV of WBSF in the progeny of tough bulls after yr 4 was unexpected. However, the results of this study showed that genetic improvement of meat tenderness through selection using WBSF can be achieved. The genetic change in this study, however, was small. The declining breeding values (improved tenderness) of the progeny of bulls selected for toughness and the lack of greater response to selection might be attributed to several effects such as genetic variance of WBSF, insufficient selection pressure, long generation intervals relative to the length of the study, and/or random drift due to small population size.

Literature Cited

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Table 1. Summary of genetic parameters, selection differentials and generation intervals

Items	Tender bulls	Tough bulls
Realized heritability	0.32* ± 0.27	$0.21^{n.s}$ ± 0.20
Selection differential (SD)/year	-2.05^{a} ± 0.29	2.91^{b} ± 0.37
Cumulative SD (lb)	-13.54	13.36
Generation interval	3.88 ± 0.53	3.85 ± 0.28
Variance components:		
σ^2_d	0.34 ± 0.17	
σ^2_d	0.85 ± 0.08	
h^2_d	0.40 ± 0.18	

^{abc}Means with the same superscript in the same row are not significantly different at P<0.05.
*(P<0.01) $^{n.s}$ (P>0.05)
$h^{2e}_{d}$is the estimate of heritability from ASREML analysis

Table 2. Least squares means and standard error for WBSF and the EBV for WBSF of the progeny of tough and tender bulls

	WBSF (lb)		EBV for WBSF (lb)	
Year	Tough	Tender	Tough	Tender
1	10.71^{a} ± 0.51	8.82^{b} ± 0.51	0.93^{i} ± 0.20	-0.40^{j} ± 0.20
2	7.94^{c} ± 0.60	7.10^{c} ± 0.66	1.12^{k} ± 0.22	-0.93^{i} ± 0.26
3	7.64^{d} ± 0.66	7.54^{d} ± 0.42	0.90^{m} ± 0.24	-0.51^{n} ± 0.15
4	6.28^{e} ± 0.46	5.93^{e} ± 0.46	0.53^{p} ± 0.18	-0.49^{q} ± 0.18
5	7.80^{f} ± 0.42	5.97^{g} ± 0.49	0.82^{r} ± 0.15	-0.57^{s} ± 0.18
6	6.83^{h} ± 0.49	6.17^{h} ± 0.44	0.49^{t} ± 0.18	-0.55^{u} ± 0.18

$^{a-u}$Means with the same superscript in the same row are not significantly different at P<0.05.