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Selecting for Carcass Marbling and Muscling – Benefits and Pitfalls

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SELECTING FOR CARCASS MARBLING AND MUSCLING-BENEFITS AND PITFALLS

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INTRODUCTION

Large premiums for Choice quality grade carcasses versus Select carcasses and substantial discounts for Yield Grade 4 carcasses provide incentive for beef cattle breeders to select for carcass traits. Marbling may only account for a small share of the variation in palatability of cooked beef products and is less important than tenderness, but it serves as an "insurance policy" for eating satisfaction and is more easily measured. Thus breeders have responded to increased consumer demand for beef quality and consistency by selecting for marbling as it is one of the few tools available to them. Without doubt, success of programs such as Certified Angus Beef have drawn attention to quality grade as a tangible component of many grid based programs. Although discounts for poor Yield Grade exist, there are only minimal premiums for superior lean yield in Y1 and Y2 carcasses. As long as single trait selection for either marbling or muscling is avoided and balanced multiple trait selection is used, small but positive gains in carcass traits should be realized.

The difficulty lies in achieving the optimum balance of traits especially considering the powerful impact of reproduction and production traits on ranch profitability. Ranchers should match their cattle (cows) to ranch resources first and adjust carcass traits only as much as ranch resources reasonably allow. There is a need to explore the antagonisms that exist between carcass traits and other reproduction and production traits. The number of bulls, within a given breed, that have genetic estimates (EPD) for carcass traits has grown rapidly in recent years. Commercial DNA tests exist for a component of marbling and tenderness. Ultrasound has contributed greatly to the carcass database and will likely increase even more because it is a direct, non-invasive measure that can be used directly on seedstock. The advent of sophisticated identification procedures and greater traceability of cattle will enhance the collection of even more carcass data. Although not all ranchers will choose to track carcass quality and quantity traits , it is clear that many of their competitors will.

HERITABILITY OF CARCASS TRAITS

Heritability is a measure of the proportion of variation in a trait that is due to genetics or genes. Highly heritable traits (.50 to .70) are greatly influenced by genetics and to a lesser extent by the environment. Lowly heritable traits (<.20) are greatly influenced by environment. Table 1, shows carcass traits as a group are more highly heritable than production traits and much more heritable than reproduction traits. Highly heritable traits are usually best changed by direct selection for that trait and lowly heritable traits usually respond best by using crossbreeding to take advantage of heterosis and complementarity.

Just because a trait happens to be heritable doesn't mean that breeders should automatically select for that trait. Other factors, such as the amount of variation in the trait, the potential selection intensity, the economic importance of the trait, the cost of measuring the trait and the genetic correlation with other traits have to be considered carefully.

TABLE 1. **HERITABILITY (h^2) OF BEEF CATTLE PERFORMANCE TRAITS**

Trait	Number of Studies[a]	Weighted Mean h^2 [b]
Reproduction Traits		
Age at First Calving	7	.06
Calving Date	7	.08
Calving Interval (Cows)	3	.01
Calving Interval (Heifers)	7	.06
Calving Ease (Direct)	19	.10
Calving Ease (Maternal)	11	.09
Calving Rate	9	.17
Scrotal Circumference	25	.48
Heifer Conception Rate (Direct)	9	.05
Cow Conception Rate (Direct)	21	.17
Production Traits		
Birth Weight (Direct)	167	.31
Birth Weight (Maternal)	34	.14
Weaning Weight (Direct)	234	.24
Weaning Weight (Maternal)	38	.13
Yearling Weight (Direct)	147	.33
Yearling Weight (Maternal)	6	.06
Mature Cow Weight	24	.50
Feed Efficiency	25	.32
Feed Intake	21	.34
Relative Growth Rate	12	.22
Yearling Frame Score	27	.61
Carcass		
Backfat	26	.44
Ribeye Area	16	.42
Slaughter Weight	52	.41
Carcass Weight	19	.23
Dressing Percentage	13	.39
Cutability	12	.47
Lean: Bone Ratio	4	.63
Marbling Score[c]	12	.38
Warner-Bratzler Shear Force	12	.29
Sensory Panel Tenderness	3	.13

(Adapted from Koots et al., 1994a and Green, 1999).

[a]Number of research studies represented.

[b]Average heritability of trait, weighted by number observations in studies. Expressed as a percentage.

[c]Recent review of Marston et al. (1999) reported average of 43% heritability for marbling.

[d]All traits are expressed on an age constant basis where applicable.

GENETIC TREND IN CARCASS TRAITS

Genetic trend for carcass traits based on actual slaughter carcass data in the Fall 2003 Angus Sire Evaluation (Figure 1 & 2) reveal how quickly Angus breeders have applied selection pressure to change carcass marbling and ribeye area. Angus sires born in recent years clearly have greater levels of genetic marbling and ribeye area as opposed to sires born in the early nineties. Angus carcass data based on ultrasound measures for intramuscular fat % (IMF%) and ribeye area show similar responses. The number of ultrasound records in the Fall 2003 Angus Sire Evaluation totals 294,515 cattle as compared to 70,520 cattle with actual slaughter carcass data.

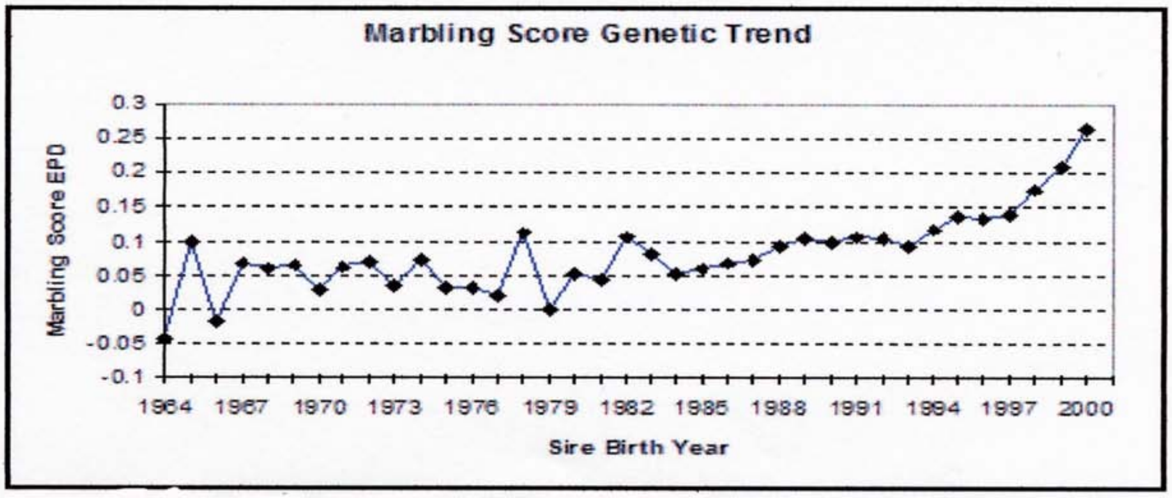

Figure 1. Genetic trend for marbling score.

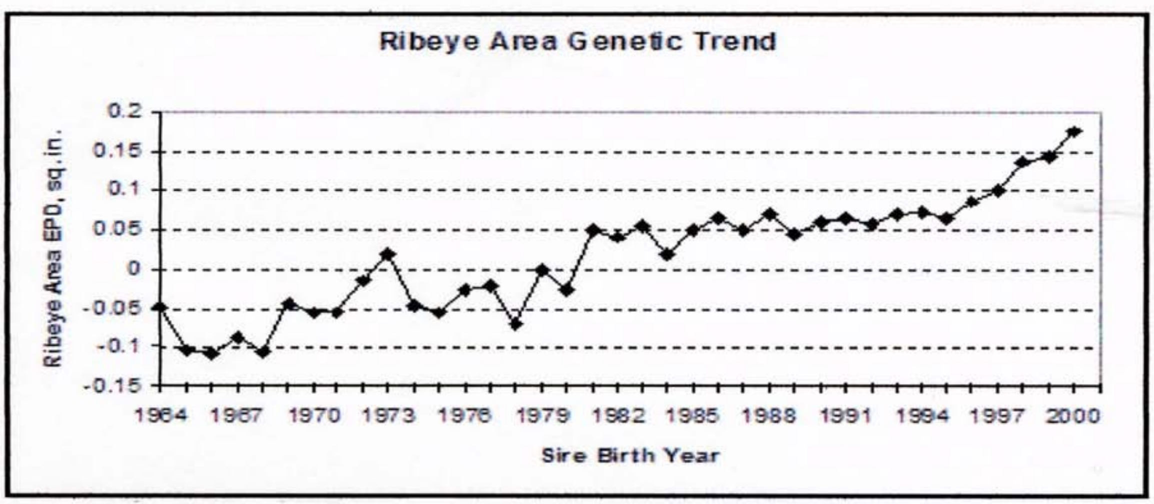

Figure 2. Genetic trend for ribeye area.

GENETIC ANTAGONISM BETWEEN TRAITS

Genetic correlation estimates the impact that selection for one trait would have on a second trait. Genetic correlation occurs because some genes have multiple effects and change does not occur in a vacuum, inevitably other traits are affected. Sometimes genetic correlation between traits can benefit selection, such as the beneficial correlation between growth rate and feed conversion. Feed conversion is difficult and costly to measure but the beneficial correlation with growth rate means selection for growth rate will also result in improvement in feed conversion.

Some carcass traits are negatively correlated to each other (marbling and leanness) and to other traits of economic importance. These antagonistic genetic correlations make selection more difficult and the response to selection will be smaller and slower to achieve.

Table 2. shows genetic correlations between many carcass traits and other productivity traits as summarized from a large number of research studies. Reflection on this table quickly points to some important antagonistic correlations between traits. For example, the positive genetic correlation between birth wt. and weaning weight (.50) means that unlimited selection for weaning weight would produce increasing birth weight and eventually unacceptable calving difficulty.

More specific to this discussion is the genetic correlation between ribeye area and marbling (-.21) and that between marbling and yearling weight (-.33). Although both pairs of the above traits would be desirable, the unfavorable genetic correlation will slow response to selection for both traits in each pair.

There are few studies reported that estimate genetic correlations between carcass traits and reproduction traits. However, MacNeil (Table 3) found low fat trim in steers was associated with higher age at puberty, lower conception rate, higher calving difficulty and larger mature weight in half-sib females.

TABLE 2. **GENETIC CORRELATIONS BETWEEN VARIOUS PERFORMANCE TRAITS**[a]

Traits[b]	Genetic Correlation
Calving Ease / Birth Weight	-0.74
Birth Wt / Feed Efficiency	-0.46
Yearling Wt / Feed Efficiency	-0.60
Feed Intake / Feed Efficiency	0.71
Wean Maternal / Feed Intake	0.80
Scrotal Circumference / Feed Efficiency	0.61
Birth Wt / Weaning Wt	0.50
Birth Wt / Yearling Wt.	0.55
Weaning Wt / Yearling Wt	0.81
Weaning Wt / Mature Wt	0.57
Weaning Wt / Slaughter Wt	0.79
Yearling Wt / Slaughter Wt	0.56
Yearling Wt / Scrotal Circumference	0.39
Backfat / Feed Intake	0.44
Backfat / Scrotal Circumference	0.78
Carcass Wt / Birth Wt	0.60
Carcass Wt / Yearling Wt	0.91
Cutability / Yearling Wt	0.87
Marbling / Yearling Wt	-0.33
Marbling / Feed Intake	0.90
Marbling / Cutability	0.35
Ribeye Area / Weaning Wt	0.49
Ribeye Area / Yearling Wt	0.51
Ribeye Area / Slaughter Weight	0.43
Ribeye Area / Cutability	0.45
Ribeye Area / Marbling	-0.21
Tenderness / Marbling	?????
Tenderness / Cutability	?????

[a]Estimates shown are taken from Koots et al. (1994b) and represent the weighted mean of available literature estimates.

[b]Traits represented are expressed on an age constant basis where appropriate and represent direct genetic effects.

TABLE 3. **GENETIC CORRELATIONS BETWEEN CARCASS TRAITS AND REPRODUCTIVE TRAITS.**

Female Trait	Postweaning Gain	Carcass	Fat Trim Wt.	Retail Product Wt.
Age at Puberty	.16	.17	-.29	.30
Wt at Puberty	.07	.07	-.31	.08
Conceptions Service	1.33	.61	.21	.28
Gestation Length	-.10	.03	-.07	.13
Calving Difficulty	-.60	-.31	-.31	-.02
Birth Weight	.34	.37	-.07	.30
Mature Weight	.07	.21	-.09	.25

MACNEIL ET AL., (1984)

THE PROMISE OF DNA TECHNOLOGY

Identification of quantitative trait loci (QTL) for some traits and the development of commercial DNA tests for certain carcass traits (marbling, tenderness) provide additional tools for including carcass traits in selection programs. Although these DNA tests only explain a portion of the variation in marbling and may be cost prohibitive for some commercial producers, they offer seedstock breeders the option to screen young bulls for further progeny testing. Such "markers" for major gene effects can be coupled with traditional selection using EPD's to result in the long-awaited reality of "marker assisted selection".

CONQUERING ANTAGONISTIC TRAITS WITH HETEROSIS AND COMPLEMENTARITY

Beef breeds have been well characterized by research at the U.S. Meat Animal Research Center and other stations for a wide spectrum of reproduction, production and carcass traits. Although there is important variation within breeds as evidenced by the range in genetic merit found in beef breed sire evaluation programs, there are clearly major differences between breed means for almost every trait measured.

Selection to jointly improve antagonistic carcass traits like marbling and muscling within a single breed is difficult. However, there are "outlier" or "curve-bender" bulls that defy some of the antagonisms between traits, but they are rare and short of artificial insemination don't exist in sufficient number to have immediate impact on the commercial segment of the beef industry. For example, in the Fall 2003 Angus Sire Evaluation there are 3,172 sires listed but only four of those bulls are at least three standard deviations (top 1 % of bulls) above breed average for both marbling and ribeye area.

Complementarity or the matching of strengths of one breed to weaknesses of another breed may be the best way to conquer antagonisms between traits, especially carcass traits. This concept is best demonstrated by the improvement in net merit of British X Continental crossbred steers that benefit from the marbling input of a British breed and the lean muscle growth of a Continental breed.

Heterosis through crossbreeding reduces the risk of adapting beef cows to the many varied resource environments in which beef cattle are expected to produce. Heterosis is also the best counter-balance to any potential negative effects that carcass traits might have on reproductive traits.

SUMMARY

1. Joint improvement in marbling and lean muscle growth will be limited by the negative genetic correlation between the two traits.
2. The number of sires with genetic estimates for carcass traits will continue to increase due mainly to data collected via ultrasound.
3. DNA markers for major gene effects hold promise to supplement traditional selection tools (EPD's) to yield more precise selection for carcass traits.
4. Crossbreeding can be used to temper antagonistic carcass traits through complementarity or the matching of breed strengths and weaknesses.
5. Heterosis is the best tool to maintain cow reproductive performance and fitness to the environment while attempting to change carcass traits.

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