Genetics and marbling

Texas scientist finds variation affects marbling, from research design to cattle type and management

By Steve Suther

Marbling drives value-based beef marketing. How to infuse enough of this quality-grade potential into herd genetics – or even how much is enough – has remained something of a mystery.

That's partly because of the wide range of research results and subsequent advice to producers, along with a segmented beef supply chain and erratic market signals.

Beef producers who select for quality may already know marbling is "moderately to highly heritable." They may even know that average heritability is near 45%, and understand that is defined as the part of the variance in a trait that you see, after allowing for environmental factors.

Looking at expected progeny differences (EPDs) and the upward trend in marbling EPDs, anyone can see that selection for greater marbling is effective. But one advisor says back away from selection for marbling because you have an adequate amount, while another says you should maximize it as long as you avoid single-trait selection for marbling.

What was missing until now was a comprehensive review of research into the genetics of marbling, and some reflection on the upshot. Texas A&M geneticist Andy Herring recently completed the white paper, "Genetic aspects of marbling in beef carcasses." The literature review encompasses 52 studies spanning several decades.

After a section on breed comparison studies, in which Angus cattle demonstrate a superior ability to marble, Herring highlights several studies.

Those included comparisons of high- and low-marbling-EPD registered Angus bulls bred to composite cows at the USDA Meat Animal Research Center. The top bull EPDs were +.33 and the low bulls were -.35 in the 1995 Angus Sire Summary, but fat thickness EPD was similar for all. Progeny were fed and harvested in two groups 60 days apart.

Calves from high-marbling bulls averaged 52% and 96% Choice, compared to 17% and 78% Choice for the progeny of low-marbling EPD bulls, while Yield Grades did not vary significantly. Further analysis suggested the higher marbling progeny also may have a faster rate of marbling deposition.

Herring didn't look into every marbling study, but his focus on correlations among carcass traits found diversity in results.

Producers may not realize the great variations that are part of the research legacy into heritability of marbling, or its correlation to other traits. Despite the range, research has demonstrated that selection can increase marbling ability without increasing external fat and without causing detrimental effects on other traits in the feedlot or on the ranch.

Wide ranges

Although the marbling heritability average estimate is .45, the reported range has been from .12 (barely worth the selection effort) and .88, or 88% effective selection. Echoing the differences in marbling ability across breeds and within breeds, the amount of genetic variation itself varies, and the relationship of marbling to other traits is probably not constant across all breeds, Herring says (see Table).

Scientists look at the standard deviation (SD) to see how uniformly and efficiently a trait will respond to selection. The phenotypic SD for marbling "has ranged from ½ to ¾ of a marbling score across several studies with diverse cattle populations," he notes.

What does that mean? At the .75 SD, "the expected range in the population is six SD, or 4.5 marbling scores from top to bottom," Herring says. The USDA Prime-to-Standard range rings true, considering typical commodity feedlot cattle in the U.S. What's more, the variability in external fat appears to be larger on average than that for marbling or intramuscular fat (IMF).

Beyond the SD ranges, heritability estimates for external fat have varied "considerably," to say the least, with a range of .02 to .86 across several studies.

"Although fat thickness is thought of as the result of feeding management, there are significant genetic differences when cattle are subjected to the same environment," Herring says.

Phenotypic correlation estimates between marbling and fat thickness have ranged from slightly negative to moderately positive.

"That means fat thickness phenotype alone may only describe 0.64% to 9% of the variation in marbling," the Texas geneticist explains. For detailed tables and bibliographies of the original studies, see Herring's white paper at www.CABpartners.com .

The phenotypic correlation (what we see) between marbling and fat thickness is low and the genetic correlation is not much higher. Yet, millions of fed cattle are marketed on grids each year, based primarily on estimated external fat thickness.

Looking ahead

Ultrasound evaluation of body composition helps predict marbling at all stages from the feedlot back to the seedstock operation, where it can contribute to the marbling-score expected progeny difference (EPD). Emerging genetic tests can be useful in predicting marbling ability, too.

"A high-accuracy EPD is more informative than any single genetic test," Herring says, "but genetic test results are available immediately." The industry expects much more progress in genetic tests in the next decade.

Marbling-related research has varied in methodology of carcass end-point constant, from age to weight to fat-thickness basis. Most genetic research has used an age-constant basis, while nutritional studies have favored a fat constant. Herring calls for more research that looks at both constants in the same trial, "especially as age verification programs become more popular."

Looking ahead, he says the beef industry needs to find better ways to evaluate and incorporate herd and calf genetic and management factors when evaluating marbling ability and other carcass traits.

"Several reports document the influence of animal age at harvest, age of dam, effects of creep feeding, individual year-effects, and other traits that may be viewed today as 'nuisance' variables," Herring says. "Nuisance, in the sense that they are generally not known on most feedlot cattle, yet variation in these types of effects could mask genetic differences if not documented."

A cattle feeding and marketing system that must make the most out of unknown potential calves is inefficient by nature, he points out. "Cattle of differing genetics are fed and managed the same because their potential is ineffectively projected based on appearances or stereotypes," Herring says.

"The main point about cattle that grade Prime is that they have the genetic ability to marble, and it is not because they are fat," he says, noting results of three National Beef Quality Audits (See Fig. 1). "Although Prime carcasses are rare, the percentage grading Prime varies little across fat thickness levels."

As producers apply selection pressure to get a few more Primes along with pounds, cows change. Herring says there's a shortage of research that relates carcass traits with cow traits, but they suggest mature cow weight and height may be lowly, negatively correlated with marbling score. Cow body condition score seems not correlated with marbling, slightly with carcass weight and moderately with fat thickness of steers.

As an illustration of the .81 genetic correlation of mature cow weight with carcass weights, Herring points to the much heavier cows of the late 1990s versus those of the 1970s (Fig. 2), and the well-known steady increase in carcass weights over time. "Within beef production systems, we must always consider the relationships between cowherd and end-product traits," he concludes.

END (but see following Table, Figures)

Genetic (shaded columns) and phenotypic correlations between marbling and other carcass traits, with marbling heritability estimate

CWT	----	REA	----	FAT	----	KPH	----	%RP	----	Shear	----	Cattle type	Heritability	Source
genetic	phenotypic	genetic	phenotypic	genetic	phenotypic	genetic	phenotypic	genetic	phenotypic	genetic	phenotypic		h^2 estimate*	
0.25	0.13	-0.14	0.03	0.16	0.24	0.29	0.18	-0.37	-0.37	-0.25	-0.12	GPE Cycles I-III	0.4	Koch et al. (1982)
0.33	-	-0.01	-	0.19	-	-	-	-	-	-	-	Hereford steers	0.35	Arnold et al. (1991)
-0.06	0.08	-0.04	-0.01	-0.13	0.12	-	-	-	.18a	-	-0.11	Angus field records	0.26	Wilson et al. (1993)
-0.03	0.09	-0.37	-0.06	0.01	0.14	-	-	.19a	.34a	-0.55	-0.15	GPE Cycle IV	0.73	Wheeler et al. (1996)
0.44	0.2	-0.36	-0.1	0.42	0.29	-	-	.60a	-0.49	-0.3	-0.15	GPE Cycle V	0.57	Wheeler et al. (2001)
-0.98	0.05	-0.82	-0.09	0.53	0.28	-	-	-0.77	-0.41	-0.03	-0.28	GPE Cycle VI	0.35	Wheeler et al. (2004)
0.18	0.14	-0.5	-0.1	0.46	0.17	-	-	-0.67	-	-0.46	-0.23	GPE Cycle VII	0.59	Wheeler et al. (2005)
-0.27	0.1	-0.36	-0.04	0.2	0.22	-0.19	0.03	-	0.36	-0.56	-	NCBA carcass merit	0.76	Thallman et al. (2004)
0.36	-0.14	0.02	0.34	-0.04	-0.08	-	-	0.09		-	-	Japanese Wagyu at 28 mo	0.52	Mukai et al. (1995)
0.01	-	-0.5	-	0.26	-	-	-	-0.37		-	-	Australian Angus		Reverter et al. (2000)
-0.49	-	0.28	-	0.39	-	-	-	-0.57	-	-	-	Australian Hereford		Reverter et al. (2000)
0.27	-	-0.1	-	0.38	-	-	-	-	-	-	-	Angus steers (age constant)		Kemp et al. (2002)
-	-	-0.26	-	0.29	-	-	-	-	-	-	-	Angus steers (weight constant)		Kemp et al. (2002)
-0.32	0.04	-0.61	-0.05	0.3	0.19	-	-	-	-	-	-	Continental-British steers (age c.)		Devitt and Wilton (2001)
-0.03	0.15	-0.37	0.04	-	-	-	-	-	-	-	-	Continental-British steers (fat c.)		Devitt and Wilton (2001)
-	-	-0.35	-0.09	0.41	0.19	-	-	-	-0.16	-	-	Cont.-British steers (weight c.)		Devitt and Wilton (2001)
0.3	0.09	0.46	0.02	0.17	0.11	-	-	0.01	-0.09	-	-	Simmental & Sim.-sired (age c.)		Shanks et al. (2001)
-	-	0.26	-0.03	0.18	0.11	-	-	0.05	-0.07	-	-	Simmental & Sim.-sired (weight c.)		Shanks et al. (2001)
0.2	0.05	0.48	0.02	-	-	-	-	0.06	-	-	-.01 to .16	Simmental & Sim.-sired (fat c.)	.12 to .36	Shanks et al. (2001)
-.15 to .11	.10 to .40	-.11 to -.01	-.26 to .22	-.03 to .05	.25 to .28	.02 to .07	-.22 to .03	-	-0.19	-.24 to -.06	-	Angus, Brahman & composite (fat c.)	.13 to .23	Elzo et al. (1998)
0.39	0.17	0.44	0.12	0.56	0.3	0.27	0.18	-0.43	.22a	-	-	Brahman	0.44	Riley et al. (2002)
-0.1	0.09	-0.17	0.2	0.26	-0.08	0.1	0.1	.26a	-0.43	-	-0.24	Shorthorn	0.88	Pariacote et al. (1998)
0.31	0.13	-0.02	-0.05	0.44	0.25	-	-	-0.6	-	-1		GPU purebreds and composites	.45 to .55	Gregory et al. (1995)

a. Reported Yield Grade rather than retail product %

* h^2 is the percentage of the total phenotypic variation that is due to additive genetic variation.

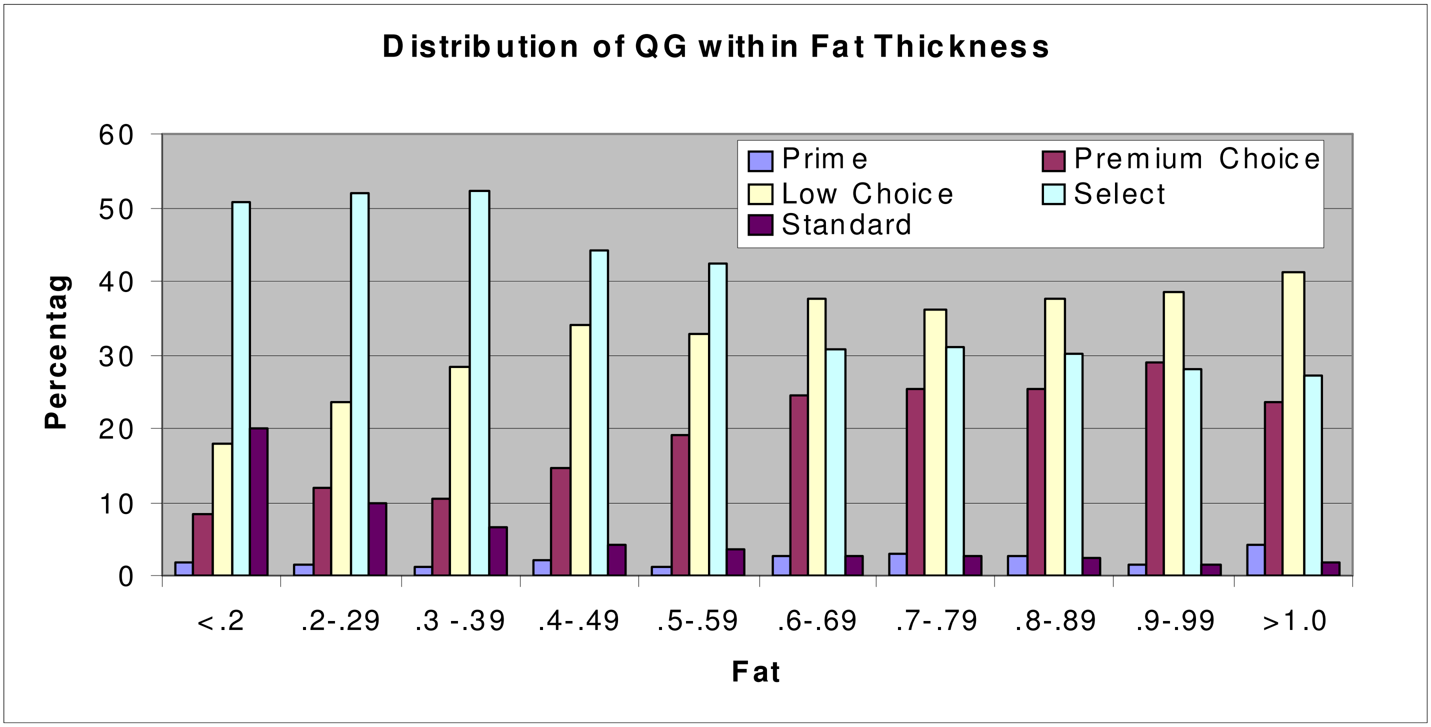

Figure 1. Distribution of quality grade percentages within each level of fat thickness from 2000 NBQA (Summarized by Dan Hale, Texas AgriLife Extension).

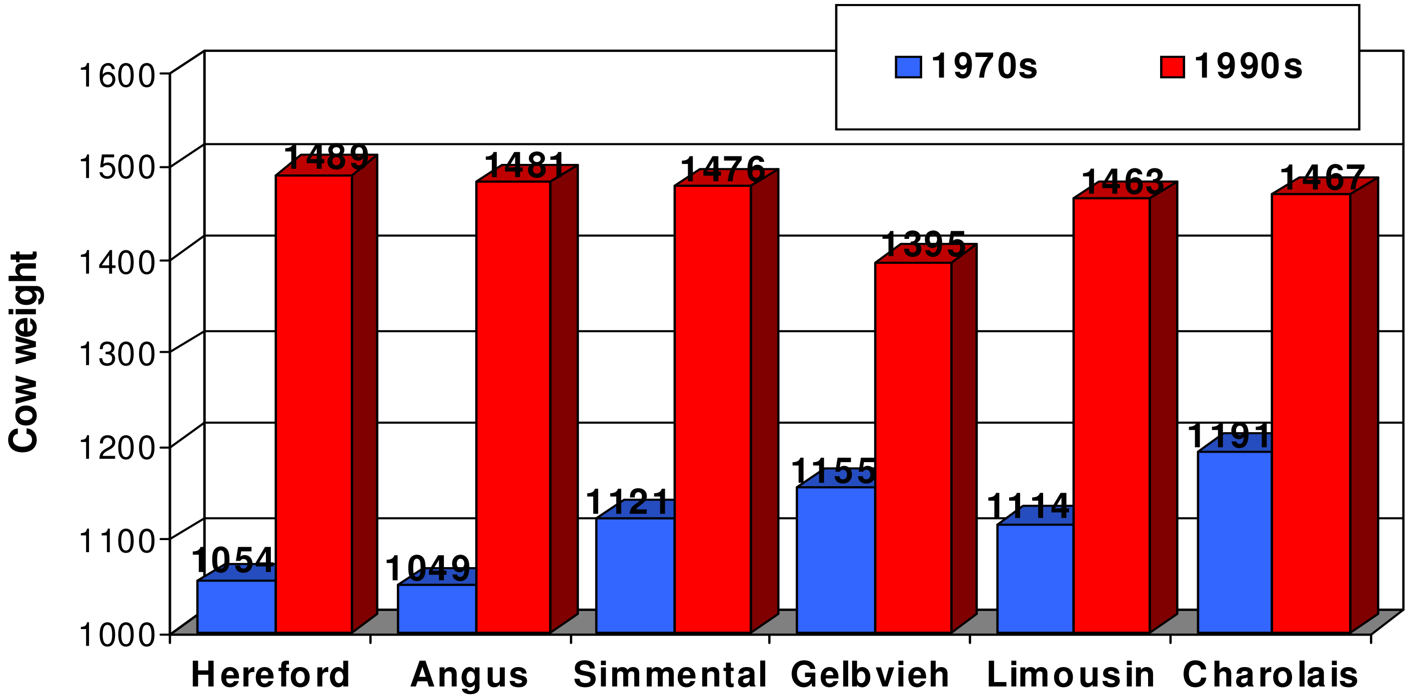

Figure 2. Average cow weights at five years of age from breeds evaluated in Germplasm Evaluation (GPE) Program at MARC, Clay Center, Neb.