What Have We Learned About Trait Relationships?

W. Herring
North Florida Research and Education Center
University of Florida, IFAS
Marianna, Florida

Introduction

Because of their maternal adaptability to tropical and sub-tropical environments, Brahman (American Zebu) influenced cattle are predominate to Florida and much of the Southern United States. We know that increasing the percentage of Brahman genes results in favorable heterosis for most production and reproduction traits (Franke, 1980), but generally results in carcasses that are tougher with lower degrees of marbling (Marshall, 1994 and O'Connor et al., 1997). Today, the *Bos indicus* x *Bos taurus* breed registries (Beefmaster, Braford, Brangus, Simbrah, etc.) compute Expected Progeny Differences (EPD) for many economically important growth and in some instances carcass traits (ASA, 2002; BBU, 2002; IBBA, 2002; UBB, 2002). However, EPD are not available for other economically important traits such as cow maintenance, post-weaning feed efficiency, and mature size. Therefore, when selecting sires based upon EPD, ranchers should be aware of the relationships that exists between traits for which EPD are available and those that they are not.

Genetic Relationships - Defined

A genetic relationship results when two traits are controlled in part by the same genes or linkage of the genes controlling the traits exists. Genetic relationships are most often quantified with genetic correlations. Genetic correlations range from –1 to +1, with an absolute value approaching one indicating a higher degree of genetic relationship between the two traits. If two traits were genetically unrelated then the genetic correlation between them would be close to zero. Unless otherwise indicated, in this paper, genetic correlations were taken from AAABG (2002), a web-site that has compiled genetic parameters from studies abroad.

Genetic correlations simply describe the existing relationships among measured traits for a population. They do not describe the trait relationships for any single animal. For example, the average genetic correlation between birth weight direct and weaning weight direct is .46 (AAABG, 2002), indicating a moderate and positive relationship between the traits. This would indicate that if you were to single-trait select for birth weight, then as a correlated response, an increase in weaning weight would also be expected. However, not every bull's genotype follows this relationship. Since EPD are available for both traits and multiple trait selection for those traits has been practiced by many seedstock producers, there are many bulls within each breed that defy the .46 genetic correlation. Without EPD, the identification and subsequent selection of these bulls would not be possible. For example, within the American Angus Association genetic evaluation, there are 73 sires that have EPD for birth weight of no more than 1.1 lbs and weaning weight of at least 41 lbs. (AAA, 2002). These EPD rank those 73 sires within the top 20% of the breed for each trait. From this database search, because of the moderate genetic correlation between the two traits, relatively few bulls meet these criteria. However, because each bull has been genetically described, those that defy the antagonism have been identified.

Most economically important traits are genetically related and in ways that are unfavorable to identifying bulls that maximize profit. As more traits are added to the selection process, it becomes more difficult to identify bulls that do all things well. In the Angus example, if a further restriction of using bulls with intramuscular fat EPD of at least .08 is added, then only 18 bulls are returned as candidates for selection.

In Table 1, many of the Brahman derivative breeds that are widely used in Florida have EPD for birth weight, weaning weight, yearling weight and milk production, and some have EPD for scrotal circumference and carcass traits. There are several economically important traits for which EPD are not available. If selection is being practiced on existing growth EPD, then we should be interested in existing genetic relationships between those traits for which we have EPD and those economically important traits we do not. Otherwise, undesirable responses in the traits for which we do not have EPD could result. Therefore, tables 2 and 3 provide genetic correlations of birth weight direct, weaning weight direct and post-weaning gain (yearling weight EPD = weaning weight EPD + post-weaning gain EPD) with efficiency and carcass traits, respectively.

Genetic Relationships – Efficiency Traits

Table 2 presents genetic correlations between growth and efficiency traits. Post-weaning gain is moderately to highly related to feed conversion (gain/feed), feed efficiency (feed/gain) and feed intake, simply indicating that cattle that grow faster consume more and probably do so more efficiently. Feed intake is highly related to birth weight direct, weaning weight direct and post-weaning gain, illustrating increased consumption follows with greater growth genetics. Depending on current year's feed prices and system of production, feed costs can range between $200 to 300 for terminal calves from back-grounding through harvest. While feed intake and growth traits are moderately genetically correlated, they are not perfectly related, indicating that animals with high growth and relative low feed intake genes could be identified if individual intake data were available. For example, if animals could be identified that defy the genetic antagonism and 10 to 20% reduction in feed costs were achieved without sacrificing growth, then net return would be improved by at least $20 to 30/hd in terminal cattle. Even though feed intake is genetically controlled (h^2=.41; AAABG, 2002), there is no mechanism in place to gather individual intake data on a broad scale. Unfortunately, these data are necessary to compute meaningful EPD for feed consumption.

Approximately 70% of the energetic cost for a cow production year is attributable to maintaining the cow (Jenkins and Ferrell, 1983). Associated costs include pasture fertilization, winter annual seed, perennial establishment, supplement, hay, depreciation on feeding or haying equipment, etc. It is reasonable that these costs could total from $200 to 400/cow/year. Unfortunately, very little information is available about relationships that exist with cow intake or more specifically, energy required for maintenance and lactation with other economically important traits. Metabolic body weight has been assumed to be linearly related with cow maintenance requirements (NRC, 2000). Therefore, the large, positive genetic relationships of growth traits with mature cow weight are noteworthy as illustrated in Table 2. Kaps et al. (1999) reported a genetic correlation between weaning weight and mature cow weight of .85 in Angus cattle. Further, Bullock et al. (1993) and Northcutt and Wilson (1993) reported genetic correlations of .89 and .45 of yearling weight with mature cow weight.

Some studies have described the positive relationship between maintenance energy requirement per unit of metabolic body weight and milk production (Jenkins and

Ferrell, 1983; Ferrell and Jenkins, 1984). In fact, Ferrell and Jenkins (1984), describing across-breed variation, illustrated that cow types with higher milk production potential had higher maintenance requirements than cows with lower milk production potential. It is unclear if this same phenomenon holds true within breed. However, if it does, cattlemen should beware when selecting sires with higher milk EPD, particularly in breeds with higher levels of milk production. Resulting females with high milk production genotypes could have higher maintenance requirements than those with low milk production genotypes.

If we think of a beef production system in terms of traits that impact profit or more specifically, individual costs and returns, it is quickly apparent there is no means of directly selecting for the most important variable that can be controlled through selection, feed/forage intake. MacNeil and Mott (2000) have attempted to use maternal pre-weaning gain EPD to predict cow energy requirements. However, as they accurately point out, individual animals whose genetic potential for intake and growth are interrelated differently than the general population cannot be identified without individual measurements for feed/forage consumption. Therefore, multiple-trait selection to simultaneously improve feed required and output traits is greatly hampered. This is true for both feed intake in feedlot cattle and forage consumption in the reproducing cow.

Genetic Relationships – Carcass Traits

Not all breeds yet compute carcass EPD. Therefore, Table 3 provides genetic correlations between growth and carcass traits. The most notable relationships are with carcass weight and ribeye area. Since carcass weight is a direct function of live harvest weight, genetic correlations with carcass weight are moderate and positive, indicating that selection for higher growth should also lead to heavier carcasses. Also, there is a moderate, positive genetic correlation with ribeye area and all of the listed growth traits. In other studies, Moser et al. (1998) and Kemp et al. (2002) have reported genetic correlations of .60 and .45, respectively, between yearling weight and ribeye area.

In recent years, there has been interest in using ultrasound measurements from yearling seedstock to produce EPD for carcass traits. Initial ultrasound EPD were published by the International Brangus Breeders Association beginning in 1995. Since that time, the American Angus Association, American Hereford Association and Red Angus Association of America have incorporated ultrasound data into their genetic evaluation programs. Early concerns of using yearling bull ultrasound data to compute carcass EPD stemmed around whether yearling bull data would rank sires the same as steer carcass data.

Moser et al. (1998) reported heritabilities and genetic correlations for carcass and ultrasound (RTU) traits in Brangus and Brangus-sired cattle. The study was designed to examine genetic relationships between carcass measurements in terminal progeny with RTU measures in yearling breeding stock. No animals in this study had both RTU and carcass measures. The records were merged from data already on file with the International Brangus Breeders Association. The final data set consisted of 2,028 animals with carcass measures (1,778 steers and 250 heifers) and 3,583 head of breeding stock with both yearling weights and RTU measures (2,364 bulls and 1,219 heifers). Heritabilities for carcass fat depth, carcass longissimus muscle area, carcass weight, RTU measured fat depth, RTU measured longissimus muscle area, and yearling weight were .27 ± .05, .39 ± .05, .59 ± .06, .11 ± .03, .29 ± .04, and .40 ± .04, respectively. These heritability levels indicate that selection based on these traits should result in favorable changes in the trait(s) of interest. Genetic correlations between carcass fat depth and RTU measured fat depth, carcass longissimus muscle area and RTU measured longissimus muscle area, and carcass weight and yearling weight were .69 ± .18, .66 ± .14, and .61 ± .11, respectively. The researchers commented that these relationships between RTU and carcass measures are favorable and moderately strong and should have the potential to lead to predictable changes in carcass traits in terminal progeny.

With more integrated production systems emerging, use of RTU data from feedyard steers and heifers may become more available. Using this approach would allow for progeny testing by measuring offspring at a single time and then subsequently marketing the offspring across multiple harvest dates. If this approach was feasible, carcass data would not need to be collected. Kemp et al. (2002) estimated heritabilities and genetic correlations among RTU and carcass traits in Angus steers from a designed progeny test (Table 4). These researchers determined that RTU data gathered from feedlot steers would rank sires the same as if EPD were calculated from carcass data alone.

Heterosis Advantages Of *Bos Indicus* X *Bos Taurus* Cattle

A primary reason for exploitation of Brahman genes to produce *Bos indicus* x *Bos taurus* cows has led to substantial improvements in reproductive traits through both direct and maternal heterosis as expressed by the crossbred female. Franke (1980) provides a review of those traits in addition to Brahman breed effects compared to other *Bos taurus* breeds. In the review, he reported weighted averages from other scientific reports of 9.9, 4.7, and 12.3% heterosis for calving rate, calf survival and weaning rate, respectively, for F1 Brahman cross cows.

McDonald and Turner (1972) estimated maternal heterosis of weaning weight for 12 types of single cross cows of Angus, Brahman, Brangus, and Hereford breeds. They reported maternal heterosis estimates for weaning weight, in descending order, of 65 lbs for Brahman x Hereford dams, followed by Brahman x Angus, Brangus x Hereford, Hereford x Angus and finally, Brangus x Angus at 5 lbs. These estimates substantiate the positive maternal influence of Brahman genes in Florida’s cow herds.

Carcass Quality Concerns

While favorable production contributions are present with F1 Brahman x *Bos taurus* females, there are concerns about carcass quality traits in resulting fed offspring. Crouse et al. (1989) reported (Table 5) that as the percentage of *Bos indicus* breeding increases, shear force and sensory tenderness becomes more undesirable. Likewise, marbling score decreases as the percentage *Bos indicus* increases. This report along with similar others can be found in Marshall (1994). Unfortunately, EPD are not available for tenderness or shear force. However, many breed associations do provide EPD for marbling or intramuscular fat. Using such tools can improve the *Bos indicus* disadvantage in marbling.

Implications

The adaptability of *Bos indicus* influenced cattle to Florida’s climate and favorable degrees of heterosis in F1 females makes them a logical choice for the state’s beef production systems. Expected progeny differences are available for many but not all economically important traits. Therefore, cattlemen should be informed of genetic relationships that exist among traits for which they select and those that are not easily measured. Disregard for those relationships could lead to undesirable decreases in net return.

Literature Cited

AAA. 2002. American Angus Association. Available: http://www.angus.org. Accessed April 4, 2002.

AAABG. 2002. AAABG Genetic Parameters. Available: http://www.gparm.csiro.au/. Accessed April 4, 2002.

ASA. 2002. American Simmental Association. Available: http://www.simmgene.com. Accessed April 4, 2002.

BBU. 2002. Beefmaster Breeders United. Available: http://www.beefmasters.org. Accessed April 4, 2002.

Bullock, K. D., J. K. Bertrand, and L. L. Benyshek. 1993. Genetic and environmental parameters for mature weight and other growth measures in Polled Hereford cattle. J. Anim. Sci. 71:1737-1741.

Crouse, J. D., L. V. Cundiff, R. M. Koch, M. Koohmaraie and S. C. Seideman. 1998. Comparisons of Bos indicus and Bos taurus inheritance for carcass beef characteristics and meat palatability. J. Anim. Sci. 67:2661-2668.

Ferrell, C. L., and T. G. Jenkins. 1984. Energy utilization by mature, nonpregnant, nonlactating cows of different types. J. Anim. Sci. 58:234-243.

Franke, D. E. 1980. Breed and heterosis effects of American Zebu cattle. J. Anim. Sci. 50:1206-1214.

IBBA. 2002. International Brangus Breeders Association Sire Summary. Available: http://www.int-brangus.org/home.htm. Accessed April 4, 2002.

Jenkins, T. G., and C. L. Ferrell. 1983. Nutrient requirements to maintain weight of mature, nonlactating, nonpregnant cows of four diverse breed types. J. Anim. Sci. 56:761-770.

Kaps, M., W. O. Herring, and W. R. Lamberson. 1999. Genetic and environmental parameters for mature weight in Angus cattle. J. Anim. Sci. 77:569-574.

Kemp, D. J., W. O. Herring, and C. J. Kaiser. 2002. Genetic and environmental parameters for steer ultrasound and carcass traits. J. Anim. Sci. In press.

Marshall, D. M. 1994. Breed differences and genetic parameters for body composition traits in beef cattle. J. Anim. Sci. 72:2745-2755.

MacNeil, M. D., and T. B. Mott. 2000. Using genetic evaluations for growth and maternal gain from birth to weaning to predict energy requirements of Line 1 Hereford beef cows. J. Anim. Sci. 78:2299-2304.

McDonald, R.P. and J.W. Turner. 1972. Estimation of maternal heterosis in preweaning traits of beef cattle. J. Anim. Sci. 35:1146-1154.

Moser, D. W., J. K. Bertrand, I. Misztal, L. A. Kriese, and L. L. Benyshek. 1998. Genetic parameter estimates for carcass and yearling ultrasound measurements in Brangus cattle. J. Anim. Sci. 76:2542-2548.

NRC. 2000. Nutrient requirements of beef cattle, 7th rev. ed., update 2000. National Academic Press, Washington, DC.

Northcutt, S. L., and D. E. Wilson. 1993. Genetic parameter estimates and expected progeny differences for mature size in Angus cattle. J. Anim. Sci. 71:1148-1153.

O'Connor, S. F., J. D. Tatum, D. M. Wulf, R. D. Green, and G. C. Smith. 1997. Genetic effects on beef tenderness in Bos indicus composite and Bos taurus cattle. J. Anim. Sci. 75:1822-1830.

UBB. 2002. United Braford Breeders Sire Summary. Available: http://www.brafords.org/. Accessed April 4, 2002.

Table 1. Expected Progeny Differences computed by some Brahman-influenced breeds.

	Beefmaster	Braford	Brangus	Simbrah
Calving ease				X
Birth weight	X	X	X	X
Weaning weight	X	X	X	X
Yearling weight	X	X	X	X
Milk	X	X	X	X
Scrotal circumference	X		X	
Ribeye area			X	
Intramuscular fat			X	
External fat			X	
Carcass weight				X
Retail cuts, %				X
Marbling				X

Table 2. Genetic correlations of growth with efficiency traits[a].

Efficiency trait	Birth weight direct	Weaning weight direct	Post-weaning gain
Feed conversion	-.12	.15	-.54
Feed efficiency			.79
Feed intake	.77	.67	.52
Mature cow wt.	.61	.65	.17

[a] Taken from AAABG (2002).

Table 3. Genetic correlations of growth with age-adjusted carcass traits[a].

Carcass trait	Birth weight direct	Weaning weight direct	Post-weaning gain
Backfat	-.27	.07	.21
Cutability	.05	.42	.25
Carcass weight	.60	.84	.76
Dressing percentage	-.15	.22	.12
Marbling	.31	-.18	.07
Ribeye area	.31	.39	.23

[a] Taken from AAABG (2002).

Table 4. Age-adjusted estimates of heritability, genetic, and environmental correlations among carcass and real-time ultrasound traits in Angus steers.[a,b]

Trait[c]	HCW	LMA	FAT	MARB	YWT	ULMA	UFAT	UEE
HCW	0.48	0.32	0.49	0.01	0.81	0.40	0.37	0.02
LMA	0.58	0.45	0.09	-0.01	0.28	0.27	0.15	0.01
FAT	0.17	-0.20	0.35	0.01	0.47	0.03	0.55	0.03
MARB	0.27	-0.10	0.38	0.42	-0.03	-0.04	-0.03	0.06
YWT	0.96	0.45	0.10	0.30	0.55	0.46	0.40	-0.01
ULMA	0.78	0.69	0.15	0.30	0.71	0.29	0.23	-0.02
UFAT	0.33	-0.24	0.82	0.45	0.33	0.23	0.39	0.02
UEE	0.14	-0.19	0.33	0.90	0.19	0.16	0.38	0.51

[a] Taken from Kemp et al. (2002).

[b] Heritability estimates on diagonal, genetic correlations below diagonal, environmental correlations above diagonal.

[c] HCW = carcass weight, kg; LMA = carcass longissimus muscle area, cm^2; FAT = 12-13 rib carcass fat thickness, cm; MARB = marbling score, 4.0 = $Slight^{00}$, 5.0 = $Small^{00}$, etc.; YWT = weight at the time of real-time ultrasound, kg; ULMA = ultrasonically scanned longissimus muscle area, cm^2; UFAT = ultrasonically scanned 12-13 rib fat thickness, cm; UIMF = ultrasonically predicted percentage ether extract.

Table 5. Quality traits from varying levels of *Bos indicus* and *Bos taurus* breeding[a].

Breed group	n	Sheer force, kg	Marbling score[b]	Sensory tenderness[c]
Hereford, Angus	107	4.40	431	5.35
¼ Brahman	28	5.16	393	5.16
½ Brahman	36	5.80	351	4.93
¾ Brahman	20	6.68	306	4.51
¼ Sahiwal	35	5.64	377	4.93
½ Sahiwal	25	6.64	347	4.61
¾ Sahiwal	28	8.41	343	4.09

[a] Source: Crouse et al. (1989).

[b] 300 to 399 = slight, 400 to 499 = small.

[c] 1 = least tender to 8 = most tender.

Notes: