Across-breed EPD tables for the year 2011 adjusted to breed differences for birth year of 2009

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Summary

Factors to adjust the expected progeny differences (EPD) of each of 18 breeds to the base of Angus EPD are reported in the column labeled 6 of Tables 1-7 for birth weight, weaning weight, yearling weight, maternal milk, marbling score, ribeye area, and fat thickness, respectively. An EPD is adjusted to the Angus base by adding the corresponding across-breed adjustment factor in column 6 to the EPD. It is critical that this adjustment be applied only to Spring 2011 EPD. Older or newer EPD may be computed on different bases and, therefore, could produce misleading results. When the base of a breed changes from year to year, its adjustment factor (Column 6) changes in the opposite direction and by about the same amount.

Breed differences are changing over time as breeds put emphasis on different traits and their genetic trends differ accordingly. Therefore, it is necessary to qualify the point in time at which breed differences are represented. Column 5 of Tables 1-7 contains estimates of the differences between the averages of calves of each breed born in year 2009. Any differences (relative to their breed means) in the samples of sires representing those breeds at the U.S. Meat Animal Research Center (USMARC) are adjusted out of these breed difference estimates and the across-breed adjustment factors. The breed difference estimates are reported as progeny differences, e.g., they represent the expected difference in progeny performance of calves sired by average bulls of two different breeds (born in 2009) and out of dams of a third, unrelated breed. In other words, they represent half the differences that would be expected between purebreds of the two breeds.

Introduction

This report is the year 2011 update of estimates of sire breed means from data of the Germplasm Evaluation (GPE) project at USMARC adjusted to a year 2009 basis using EPD from the most recent national cattle evaluations. The 2009 basis year is chosen because yearling records for weight and carcass traits should have been accounted for in EPDs for progeny born in 2009 in the Spring 2011 EPD national genetic evaluations. Factors to adjust Spring 2011 EPD of 18 breeds to a common base were calculated and are reported in Tables 1-3 for birth weight (BWT), weaning weight (WWT), and yearling weight (YWT) and in Table 4 for the maternal milk (MILK) component of maternal weaning weight (MWWT). Tables 5-6 summarize the factors for marbling score (MAR), ribeye area (REA), and fat thickness (FAT).

The across-breed table adjustments apply **only** to EPD for most recent (spring, 2011) national cattle evaluations. Serious errors can occur if the table adjustments are used with earlier EPD which may have been calculated with a different within-breed base.

The following describes the changes that have occurred since the update released in 2010 (Kuehn et al., 2010). The most significant changes continue to relate to the new sampling in the USMARC GPE program. Progeny from 16 of the 18 breeds involved in the across-breed EPD process have been born (approximately 40/yr) and improve the accuracy in predicting the differences between these breeds. These 16 breeds are the breeds that register the most cattle and have national genetic evaluations for production traits. Sires are sampled on a continuous basis (every 2 years). The first progeny of this new sampling were born in Fall 2007. Adjustment factors for yearling weight and carcass traits were estimated for Santa Gertrudis and Chiangus for the first time last year. Progeny number increased for each of these breeds by approximately 35%. As numbers of bulls sampled and numbers of progeny born for these two breeds are smaller than for other breeds, their factors are the most susceptible to year-to-year changes as more progeny are produced. Maternal milk for these breeds will also be reported in future iterations of this report as daughters from these matings begin to have calves of their own. Chiangus in particular had relatively large changes in their USMARC breed of sire estimates (labeled column 3 in Tables 2 and 3) for weaning or yearling weights or both compared to last year.

Changes in national cattle evaluation can also cause across breed adjustment factors to change relative to previous years. Both Braunvieh and Chiangus had a base shift in their EPDs this year relative to the EPDs used in Kuehn et al. (2010). These changes primarily cause the adjustment (labeled column 6; Tables 1-7) factors for these breeds. Changes to sire breed differences (labeled column5) occur due to changes the mean EPDs of sires sampled for GPE relative to the breed average and due to changes in the sire breed solution (labeled column 3). Changes in the mean EPD of traits in Angus (to which every breed of sire solution difference is deviated from) can also cause changes in the sire bred differences reported. Most changes compared to Kuehn et al. (2010) were relatively minor in this year's update.

Materials and Methods

All calculations were as outlined in the 2010 BIF Guidelines. The basic steps were given by Notter and Cundiff (1991) with refinements by Núñez-Dominguez et al. (1993), Cundiff (1993, 1994), Barkhouse et al. (1994, 1995), Van Vleck and Cundiff (1997–2006), and Kuehn et al. (2007-2010). Estimates of variance components, regression coefficients, and breed effects were obtained using the MTDFREML package (Boldman et al., 1995). All breed solutions are reported as differences from Angus. The table values of adjustment factors to add to within-breed EPD are relative to Angus.

Models for Analysis of USMARC Records: An animal model with breed effects represented as genetic groups was fitted to the GPE data set (Arnold et al., 1992; Westell et al., 1988). In the analysis, all AI sires (sires used via artificial insemination) were assigned a genetic group according to their breed of origin. Due to lack of pedigree, dams mated to the AI sires and natural service bulls mated to F_1 females were also assigned to separate genetic groups (i.e., Hereford dams were assigned to different genetic groups than Hereford AI sires). Cows from Hereford selection lines (Koch et al., 1994) were used in Cycle IV of GPE and assigned into their own genetic groups. Through Cycle VIII, most dams were from Hereford, Angus, or MARCIII (1/4 Angus, 1/4 Hereford, 1/4 Pinzgauer, 1/4 Red Poll) composite lines. In order to be considered in the analysis, sires had to have an EPD for the trait of interest. All AI sires were considered unrelated for the analysis in order to adjust resulting genetic group effects by the average EPD of the sires.

Fixed effects in the models for BWT, WWT (205-d), and YWT (365-d) included breed (fit as genetic groups) and maternal breed (WWT only), year and season of birth by GPE cycle by age of dam (2, 3, 4, 5-9, >10 yr) combination (204), sex (heifer, bull, steer; steers were combined with bulls for BWT), a covariate for heterosis, and a covariate for day of year at birth of calf. Models for WWT also included a fixed covariate for maternal heterosis. Random effects included animal and residual error except for the analysis of WWT which also included a random maternal genetic effect and a random permanent environmental effect.

For the carcass traits (MAR, REA, and FAT), breed (fit as genetic groups), sex (heifer, steer) and slaughter date (224) were included in the model as fixed effects. Fixed covariates included slaughter age and heterosis. Random effects were animal and residual error. To be included, breeds had to report carcass EPD on a carcass basis using age-adjusted endpoints, as suggested in the 2010 BIF Guidelines.

The covariates for heterosis were calculated as the expected breed heterozygosity for each animal based on the percentage of each breed of that animal's parents. In other words, it is the probability that, at any location in the genome, the animal's two alleles originated from two different breeds. Heterosis is assumed to be proportional to breed heterozygosity. For the purpose of heterosis calculation, AI and dam breeds were assumed to be the same breed and Red Angus was assumed the same breed as Angus. For purposes of heterosis calculation, composite breeds were considered according to nominal breed composition. For example, Brangus (3/8 Brahman, 5/8 Angus) × Angus is expected to have 3/8 as much heterosis as Brangus × Hereford.

Variance components were estimated with a derivative-free REML algorithm with genetic group solutions obtained at convergence. Differences between resulting genetic group solutions for AI sire breeds were divided by two to represent the USMARC breed of sire effects in Tables 1-7. Resulting breed differences were adjusted to current breed EPD levels by accounting for the average EPD of the AI sires of progeny/grandprogeny, etc. with records. Average AI sire EPD were calculated as a weighted average AI sire EPD from the most recent within breed genetic evaluation. The weighting factor was the sum of relationship coefficients between an individual sire and all progeny with performance data for the trait of interest relative to all other sires in that breed.

For all traits, regression coefficients of progeny performance on EPD of sire for each trait were calculated using an animal model with EPD sires excluded from the pedigree. Genetic groups were assigned in place of sires in their progeny pedigree records. Each sire EPD was 'dropped' down the pedigree and reduced by ½ depending on the number of generations each calf was removed from an EPD sire. In addition to regression coefficients for the EPDs of AI sires, models included the same fixed effects described previously. Pooled regression coefficients, and regression coefficients by sire breed were obtained. These regression coefficients are monitored as accuracy checks and for possible genetic by environment interactions. The pooled regression coefficients were used as described in the next section to adjust for differences in management at USMARC as compared to seedstock production (e.g., YWT of males at USMARC are primarily on a slaughter steer basis, while in seedstock field data they are primarily on a breeding bull basis). For carcass traits, MAR, REA, and FAT, regressions were considered too variable and too far removed from 1.00. Therefore, the regressions were assumed to be 1.00 until more data is added to reduce the impact of sampling errors on prediction of these regressions. However, the resulting regressions are still summarized.

Records from the USMARC GPE Project are not used in calculation of within-breed EPD by the breed associations. This is critical to maintain the integrity of the regression coefficient. If USMARC records were included in the EPD calculations, the regressions would be biased upward.

Adjustment of USMARC Solutions: The calculations of across-breed adjustment factors rely on breed solutions from analysis of records at USMARC and on averages of within-breed EPD from the breed associations. The basic calculations for all traits are as follows:

USMARC breed of sire solution (1/2 breed solution) for breed i (USMARC (i)) converted to an industry scale (divided by b) and adjusted for genetic trend (as if breed average bulls born in the base year had been used rather than the bulls actually sampled):

$$M_i = \text{USMARC (i)}/b + [\text{EPD(i)}_{YY} - \text{EPD(i)}_{USMARC}].$$

Breed Table Factor (A_i) to add to the EPD for a bull of breed i:

$$A_i = (M_i - M_x) - (\text{EPD(i)}_{YY} - \text{EPD(x)}_{YY}).$$

where,

USMARC(i) is solution for effect of sire breed i from analysis of USMARC data,

$EPD(i)_{YY}$ is the average within-breed 2011 EPD for breed i for animals born in the base year (YY, which is two years before the update; e.g., YY = 2009 for the 2011 update),

$EPD(i)_{USMARC}$ is the weighted (by total relationship of descendants with records at USMARC) average of 2011 EPD of bulls of breed i having descendants with records at USMARC,
b is the pooled coefficient of regression of progeny performance at USMARC on EPD of sire (for 2009: 1.15, 0.86, 1.04, and 1.17 BWT, WWT, YWT, and MILK, respectively; 1.00 was applied to MAR, REA, and FAT data),
i denotes sire breed i, and
x denotes the base breed, which is Angus in this report.

Results

Heterosis: Heterosis was included in the statistical model as a covariate for all traits. Maternal heterosis was also fit as a covariate in the analysis of weaning weight. Resulting estimates were 1.58 lb, 12.75 lb, 17.16 lb, 0.030 marbling score units (i.e. 4.00 = Sl^{00}, 5.00 = Sm^{00}), 0.27 in^2, and 0.039 in for BWT, WWT, YWT, MAR, REA, and FAT respectively. These estimates are interpreted as the amount by which the performance of an F_1 is expected to exceed that of its parental breeds. The estimate of maternal heterosis for WWT was 16.59 lb.

Across-breed adjustment factors: Tables 1, 2, and 3 (for BWT, WWT, and YWT) summarize the data from, and results of, USMARC analyses to estimate breed of sire differences on a 2009 birth year basis. The column labeled 6 of each table corresponds to the Across-breed EPD Adjustment Factor for that trait. Table 4 summarizes the analysis of MILK. Tables 5, 6, and 7 summarize data from the carcass analyses (MAR, REA, FAT). Because of the accuracy of sire carcass EPDs and the greatest percentage of data being added to carcass traits, sire effects and adjustment factors are more likely to change for carcass traits in the future.

Column 5 of each table represents the best estimates of sire breed differences for calves born in 2009 on an industry scale. These breed difference estimates are reported as progeny differences, e.g., they represent the expected difference in progeny performance of calves sired by average bulls (born in 2009) of two different breeds and out of dams of a third, unrelated breed. Thus, they represent half the difference expected between purebreds of the respective breeds.

In each table, breed of sire differences were added to the raw mean of Angus-sired progeny born 2006 through 2010 at USMARC (Column 4) to make these differences more interpretable to producers on scales they are accustomed to.

Across-breed EPD Adjustment Factor Example: Adjustment factors can be applied to compare the genetic potential of sires from different breeds. Suppose the EPD for weaning weight for a Limousin bull is +42.1 (which is below the year 2009 average of 42.9 for Limousin) and for a Hereford bull is +44.0 (which is above the year 2009 average of 43.0 for Hereford). The across-breed adjustment factors in the last column of Table 1 are -1.5 for Hereford and 0.9 for Limousin. Then the adjusted EPD for the Limousin bull is 42.1 + 0.9) = 43.0 and for the Hereford bull is 44.0 + (-1.5) = 42.5. The expected weaning weight difference when both are mated to another breed of cow, e.g., Angus, would be 43.0 – 42.5 = 0.5 lb. The differences in true breeding value between two bulls with similar within-breed EPDs are primarily due to differences in the genetic base from which those within-breed EPDs are computed.

Birth Weight: The range in estimated breed of sire differences for BWT ranged from 0.3 lb for Red Angus to 7.1 lb for Charolais and 11.3 lb for Brahman. Angus continued to have the lowest estimated sire effect for birth weight (Table 1, column 5). The relatively heavy birth weights of Brahman-sired progeny would be expected to be offset by favorable maternal effects reducing birth weight if progeny were from Brahman or Brahman cross dams which would be an important consideration in crossbreeding programs involving Brahman cross females. Changes in breed of sire effects were generally small, less than 1 lb for all breeds relative to last year's update (Kuehn et al., 2010).

Weaning Weight: Breed effects on weaning weight remained fairly similar to last year for most breeds—all of the 17 sire breed differences were within 10 lb of the values in Kuehn et al. (2010). The average Chiangus sire breed effect was predicted 9.3 lb lighter than reported in Kuehn et al. (2010) relative to Angus. In this update, Chiangus were predicted to be 28.5 lb lighter than Angus as a sire breed; last year Chiangus were predicted to be 19.2 lb less than Angus. Sire breed effects of Braunvieh were 8.3 lb less than last year, likely due to increased sampling of sires and increases in their progeny at USMARC relative to last year. Braunvieh effects seem to be more affected by sampling since their reintroduction into the GPE project in 2007 as their sire breed mean increased by ~8 in last year's update relative to Kuehn et al. (2009). Further sampling and increases in Braunvieh-sired progeny should stabilize these year-to-year changes.

Yearling Weight: Genetic trends for yearling weight in Angus continued to increase at a rate faster than that of other breeds (from 81.5 lb average EPD in 2010 to 83 in 2011). Consequently, all breed differences relative to Angus (Table 3, column 5) decrease by at least 1.5 relative to Angus before adjustments for their own breed effect and genetic trend. Most breed of sire effect changes were relatively small (less than 10 lb) relative to Kuehn et al. (2011). The only exception was Chiangus which decreased in its sire difference relative to Angus by 13.4 lb. This was only the second year Chaingus-sired progeny were used to predict yearling weight differences; 50% more Chiangus-sired progeny were added relative to last year. Hence, their estimated breed solution from USMARC (Table 3, column 3) is still highly variable relative to most of the other breeds.

Maternal Milk: The changes from last year for milk for the current base year (Table 4, column 5) were again generally small. Differences may be more substantial in the future as more heifers from the most recent GPE sampling of bulls reach calving age. The genetic trend for milk for Angus, like that for yearling weight, has been steep relative to breeds such as Simmental and Gelbvieh. Thus sire breed differences between Simmental or Gelbvieh and Angus are relatively small compared to estimates 15 to 30 years ago.

Marbling: Marbling score was estimated to be highest in Angus (Table 5, column 5) with Red Angus being the most similar (~0.4 score units lower) of recently sampled breeds. Continental breeds were estimated to be one-half to a full marbling score lower than Angus with the exception of Salers. Progeny from Hereford sires were predicted to have the lowest marbling score relative to other British breeds.

Ribeye Area: Continental breeds had higher ribeye area estimates relative to the British breeds (Table 6, column 5) as would be expected. The estimates of sire breed differences were similar to last year for almost all breeds.

Fat Thickness: Progeny of Continental breeds had 0.1 to 0.2 in less fat at slaughter than British breeds (Table 7, Column 5). All other breeds were leaner than Angus. Charolais, Salers, Maine Anjou, and Simmental were predicted to be the leanest breeds among the 12 breeds analyzed for carcass traits. Limousin was not included in the FAT analysis because they do not report an EPD for FAT. Changes in breed of sire effects relative to Angus were all minor compared to the previous year (Kuehn et al., 2010) except for Braunvieh whose breed mean EPD changed relative to last year's analysis by a significant amount (increased by over 0.1 in). This base change actually occurred in 2010 but was not input correctly in Kuehn et al (2010).

Accuracies and Variance Components: Table 8 summarizes the average Beef Improvement Federation (BIF) accuracy for bulls with progeny at USMARC weighted appropriately by average relationship to animals with phenotypic records. South Devon bulls had relatively small accuracy for all traits as did Hereford and Brahman bulls. Charolais and Gelbvieh bulls had low accuracy for yearling weight and milk. Accuracies for carcass traits, as expected, were considerably lower than accuracies for growth traits in general. The sires sampled recently in the GPE program have generally been higher accuracy sires, so the average accuracies should continue to increase over the next several years.

Table 9 reports the estimates of variance components from the animal models that were used to obtain breed of sire and breed of MGS solutions. Heritability estimates for BWT, WWT, YWT, and MILK were 0.58, 0.18, 0.46, and 0.16, respectively. Heritability estimates for MAR, REA, and FAT were 0.45, 0.47, and 0.40, respectively.

Regression Coefficients: Table 10 updates the coefficients of regression of records of USMARC progeny on sire EPD for BWT, WWT, and YWT which have theoretical expected values of 1.00. The standard errors of the specific breed regression coefficients are large relative to the regression coefficients. Large differences from the theoretical regressions, however, may indicate problems with genetic evaluations, identification, or sampling. The pooled (overall) regression coefficients of 1.15 for BWT, 0.86 for WWT, and 1.04 for YWT were used to adjust breed of sire solutions to the base year of 2009. These regression coefficients are reasonably close to expected values of 1.0. Deviations from 1.00 are believed to be due to scaling differences between performance of progeny in the USMARC herd and of progeny in herds contributing to the national genetic evaluations of the 18 breeds. Breed differences calculated from the USMARC data are divided by these regression coefficients to put them on an industry scale. A regression greater than one suggests that variation at USMARC is greater than the industry average, while a regression less than one suggests that variation at USMARC is less than the industry average. Reasons for differences in scale can be rationalized. For instance, cattle, especially steers, are fed at higher energy rations than some seedstock animals in the industry. Also, in several recent years, calves have been weaned earlier than 205 d at USMARC, likely reducing the variation in weaning weight of USMARC calves relative to the industry.

The coefficients of regression for MILK are also shown in Table 10. Several sire (MGS) breeds have regression coefficients considerably different from the theoretical expected value of 1.00 for MILK. Standard errors, however, for the regression coefficients by breed are large except for Angus and Hereford. The pooled regression coefficient of 1.17 for MILK is reasonably close to the expected regression coefficient of 1.00.

Regression coefficients derived from regression of USMARC steer progeny records on sire EPD for MAR, REA, and FAT are shown in Table 11. Each of these coefficients has a theoretical expected value of 1.00. Compared to growth trait regression coefficients, the standard errors even on the pooled estimates are high, though they have decreased from the previous year. Each coefficient deviates from the expected value of 1.00 more than the growth trait coefficients with the exception of REA. Therefore, the theoretical estimate of 1.00 was used to derive breed of sire differences and EPD adjustment factors. The pooled regression estimates would cause USMARC differences to be larger on an industry scale for MAR and smaller on an industry scale for FAT. These regressions will change considerably in upcoming across-breed analyses as more data is added to the GPE program and new sires from most of these breeds are sampled.

Prediction Error Variance of Across-Breed EPD: Prediction error variances were not included in the report due to a larger number of tables included with the addition of carcass traits. These tables did not change substantially from those reported in previous proceedings (Kuehn et al., 2007; available online at http://www.beefimprovement.org/proceedings.html). An updated set of tables is available on request (Larry.Kuehn@ars.usda.gov).

Implications

Bulls of different breeds can be compared on a common EPD scale by adding the appropriate across-breed adjustment factor to EPD produced in the most recent genetic evaluations for each of the 18 breeds. The across-breed EPD are most useful to commercial producers purchasing bulls of two or more breeds to use in systematic crossbreeding programs. Uniformity in across-breed EPD should be emphasized for rotational crossing. Divergence in across-breed EPD for direct weaning weight and yearling weight should be emphasized in selection of bulls for terminal crossing. Divergence favoring lighter birth weight may be helpful in selection of bulls for use on first calf heifers. Accuracy of across-breed EPD depends primarily upon the accuracy of the within-breed EPD of individual bulls being compared.

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Table 1. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2009 base and factors to adjust within breed EPD to an Angus equivalent – BIRTH WEIGHT (lb)

	Number		Ave. Base EPD		Breed Soln	BY 2009	BY 2009	Factor to
			Breed	USMARC	at USMARC	Sire Breed	Sire Breed	adjust EPD
	AI	Direct	2009	Bulls	(vs Ang)	Average	Difference[a]	To Angus
Breed	Sires	Progeny	(1)	(2)	(3)	(4)	(5)	(6)
Angus	126	1680	2.0	1.8	0.0	91.8	0.0	0.0
Hereford	131	2117	3.6	2.2	3.7	96.2	4.4	2.8
Red Angus	37	512	0.0	-1.1	-0.8	92.1	0.3	2.3
Shorthorn	43	337	2.4	1.4	6.4	98.1	6.3	5.9
South Devon	15	153	2.8	1.9	5.0	96.8	5.0	4.2
Beefmaster	34	267	0.4	1.1	7.0	97.0	5.2	6.8
Brahman	49	589	1.9	0.6	11.8	103.1	11.3	11.4
Brangus	33	261	0.8	1.1	4.0	94.7	2.9	4.1
Santa Gertrudis	19	148	0.5	1.1	8.1	98.1	6.3	7.8
Braunvieh	29	339	-0.1	0.6	5.2	95.4	3.6	5.7
Charolais	95	968	0.6	0.3	8.1	98.9	7.1	8.5
Chiangus	17	159	2.1	2.7	5.2	95.5	3.7	3.6
Gelbvieh	66	879	1.3	1.1	3.6	94.9	3.1	3.8
Limousin	59	942	1.8	1.0	3.2	95.2	3.4	3.6
Maine Anjou	37	330	1.9	4.2	7.7	96.0	4.2	4.3
Salers	46	323	1.8	2.6	3.1	93.6	1.8	2.0
Simmental	66	918	0.9	2.0	5.7	95.5	3.7	4.8
Tarentaise	7	199	1.9	1.9	2.1	93.5	1.7	1.8

Calculations:

(4) = (3) / b + [(1) – (2)] + (Recent Raw Angus Mean: 91.6 lb) with b = 1.11

(5) = (4) – (4, Angus)

(6) = (5) – (5, Angus) – [(1) – (1, Angus)]

[a]The breed difference estimates represent half the differences that would be expected between purebreds of the two breeds.

Table 2. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2009 base and factors to adjust within breed EPD to an Angus equivalent – WEANING WEIGHT (lb)

Breed	Number AI Sires	Number Direct Progeny	Ave. Base EPD Breed 2009 (1)	Ave. Base EPD USMARC Bulls (2)	Breed Soln at USMARC (vs Ang) (3)	BY 2009 Sire Breed Average (4)	BY 2009 Sire Breed Difference[a] (5)	Factor to adjust EPD To Angus (6)
Angus	125	1543	46.0	25.6	0.0	594.9	0.0	0.0
Hereford	129	1959	43.0	25.4	-1.4	590.4	-4.5	-1.5
Red Angus	37	497	30.9	25.6	-1.3	578.3	-16.6	-1.5
Shorthorn	43	322	15.3	12.5	4.0	582.0	-12.8	17.9
South Devon	15	134	41.4	23.4	1.3	594.1	-0.8	3.8
Beefmaster	34	260	9.0	14.6	21.8	594.3	-0.6	36.4
Brahman	49	507	14.8	7.1	18.8	604.1	9.2	40.4
Brangus	33	252	22.6	22.4	10.0	586.4	-8.5	14.9
Santa Gertrudis	19	142	4.0	8.8	15.0	587.1	-7.8	34.2
Braunvieh	29	321	6.2	5.0	-1.9	573.5	-21.3	18.5
Charolais	94	872	24.2	12.5	23.2	613.2	18.3	40.1
Chiangus	17	150	32.0	37.1	-2.6	566.3	-28.5	-14.5
Gelbvieh	66	825	41.0	33.6	10.2	593.8	-1.1	3.9
Limousin	59	863	42.9	27.5	2.3	592.6	-2.2	0.9
Maine Anjou	37	305	39.7	41.5	5.2	578.8	-16.1	-9.8
Salers	46	307	40.2	31.5	4.8	588.8	-6.1	-0.3
Simmental	65	835	32.1	25.7	22.3	606.9	12.0	25.9
Tarentaise	7	191	16.0	-5.6	1.3	597.6	2.8	32.8

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 574.5 lb) with b = 0.84

(5) = (4) – (4, Angus)

(6) = (5) – (5, Angus) – [(1) – (1, Angus)]

[a]The breed difference estimates represent half the differences that would be expected between purebreds of the two breeds.

Table 3. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2009 base and factors to adjust within breed EPD to an Angus equivalent – YEARLING WEIGHT (lb)

	Number		Ave. Base EPD		Breed Soln	BY 2009	BY 2009	Factor to
			Breed	USMARC	at USMARC	Sire Breed	Sire Breed	adjust EPD
	AI	Direct	2009	Bulls	(vs Ang)	Average	Difference[a]	To Angus
Breed	Sires	Progeny	(1)	(2)	(3)	(4)	(5)	(6)
Angus	122	1412	83.0	47.8	0.0	1031.3	0.0	0.0
Hereford	125	1822	71.0	42.8	-23.0	1002.2	-29.1	-17.1
Red Angus	36	453	58.2	46.9	-10.0	997.8	-33.5	-8.7
Shorthorn	42	286	24.8	20.1	14.6	1014.8	-16.5	41.7
South Devon	15	134	77.3	50.3	-2.5	1020.7	-10.6	-4.9
Beefmaster	25	164	14.0	22.9	13.6	1000.2	-31.1	37.9
Brahman	43	434	23.8	11.7	-32.9	976.6	-54.7	4.5
Brangus	24	161	44.8	40.9	7.4	1007.1	-24.2	14.0
Santa Gertrudis	15	115	5.0	10.5	-13.0	978.1	-53.2	24.8
Braunvieh	21	289	12.2	11.1	-14.7	983.1	-48.2	22.6
Charolais	89	782	42.3	24.1	26.2	1039.5	8.2	48.9
Chiangus	14	123	59.5	66.5	-15.8	973.9	-57.4	-33.9
Gelbvieh	63	779	75.0	60.6	2.4	1012.8	-18.4	-10.4
Limousin	53	803	80.2	56.4	-23.7	997.2	-34.1	-31.3
Maine Anjou	34	280	78.1	84.2	8.3	997.9	-33.4	-28.5
Salers	44	280	77.4	60.5	2.2	1015.1	-16.1	-10.5
Simmental	62	737	57.9	47.4	25.1	1030.7	-0.6	24.5
Tarentaise	7	189	28.6	-3.6	-30.1	999.4	-31.9	22.5

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 996.1 lb) with b = 1.06

(5) = (4) – (4, Angus)

(6) = (5) – (5, Angus) – [(1) – (1, Angus)]

[a]The breed difference estimates represent half the differences that would be expected between purebreds of the two breeds.

Table 4. Breed of maternal grandsire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2009 base and factors to adjust within breed EPD to an Angus equivalent – MILK (lb)

	Number			Ave. Base EPD		Breed Soln	BY 2009	BY 2009	Factor to
				Breed	USMARC	at USMARC	Sire Breed	Sire Breed	adjust EPD
	AI	Direct	Direct	2009	Bulls	(vs Ang)	Average	Difference[a]	To Angus
Breed	Sires	Gpr	Progeny	(1)	(2)	(3)	(4)	(5)	(6)
Angus	104	2748	559	22.0	11.4	0.0	585.1	0.0	0.0
Hereford	112	3526	747	17.0	8.7	-25.1	561.4	-23.7	-18.7
Red Angus	25	537	127	16.7	13.0	0.2	578.3	-6.8	-1.5
Shorthorn	31	277	82	2.3	5.0	15.5	585.1	-0.1	19.6
South Devon	14	373	70	22.8	19.2	2.4	580.2	-5.0	-5.8
Beefmaster	20	271	52	2.0	-1.6	-12.2	567.7	-17.4	2.6
Brahman	36	778	186	6.3	4.3	16.8	590.9	5.7	21.4
Brangus	19	249	43	10.7	4.3	-6.8	575.1	-10.0	1.3
Braunvieh	15	555	105	0.4	-0.8	20.8	593.5	8.4	30.0
Charolais	69	1286	264	6.4	3.4	-3.9	574.1	-11.0	4.6
Gelbvieh	51	1261	267	18.0	17.2	18.7	591.3	6.2	10.2
Limousin	45	1415	284	20.9	18.3	-7.6	570.6	-14.5	-13.4
Maine Anjou	25	540	98	19.5	24.0	10.4	578.9	-6.2	-3.7
Salers	35	373	100	19.5	22.1	13.2	583.1	-2.0	0.5
Simmental	49	1396	271	3.6	7.3	13.1	582.0	-3.1	15.3
Tarentaise	6	367	80	0.6	5.3	18.6	585.7	0.5	21.9

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 574.5lb) with b = 1.20

(5) = (4) – (4, Angus)

(6) = (5) – (5, Angus) – [(1) – (1, Angus)]

[a]The breed difference estimates represent half the differences that would be expected between purebreds of the two breeds.

Table 5. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2009 base and factors to adjust within breed EPD to an Angus equivalent – MARBLING (marbling score units[a])

	Number		Ave. Base EPD		Breed Soln	BY 2009	BY 2009	Factor to
			Breed	USMARC	at USMARC	Sire Breed	Sire Breed	adjust EPD
	AI	Direct	2009	Bulls	(vs Ang)	Average	Difference[b]	To Angus
Breed	Sires	Progeny	(1)	(2)	(3)	(4)	(5)	(6)
Angus	104	621	0.43	0.19	0.00	5.80	0.00	0.00
Hereford	121	838	0.04	-0.01	-0.51	5.09	-0.71	-0.32
Red Angus	35	142	0.07	0.15	-0.04	5.44	-0.36	0.00
Shorthorn	41	152	-0.02	0.01	-0.27	5.25	-0.55	-0.10
South Devon	13	49	0.30	-0.10	-0.20	5.76	-0.05	0.08
Santa Gertrudis	13	52	0.00	-0.02	-0.86	4.73	-1.07	-0.64
Braunvieh	21	139	0.12	0.00	-0.45	5.24	-0.56	-0.25
Charolais	36	157	0.01	-0.05	-0.64	4.98	-0.82	-0.40
Chiangus	14	57	0.09	0.01	-0.56	5.08	-0.72	-0.38
Limousin	51	301	-0.04	-0.08	-0.96	4.64	-1.16	-0.69
Maine Anjou	31	138	0.20	0.13	-0.83	4.80	-1.00	-0.77
Salers	40	132	0.10	-0.34	-0.66	5.34	-0.46	-0.13
Simmental	59	324	0.15	0.07	-0.63	5.01	-0.79	-0.51

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 5.56) with b = 1.00

(5) = (4) – (4, Angus)

(6) = (5) – (5, Angus) – [(1) – (1, Angus)]

[a]4.00 = Sl^{00}, 5.00 = Sm^{00}

[b]The breed difference estimates represent half the differences that would be expected between purebreds of the two breeds.

Table 6. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2009 base and factors to adjust within breed EPD to an Angus equivalent – RIBEYE AREA (in^2)

Breed	Number		Ave. Base EPD		Breed Soln at USMARC (vs Ang) (3)	BY 2009 Sire Breed Average (4)	BY 2009 Sire Breed Difference[a] (5)	Factor to adjust EPD To Angus (6)
	AI Sires	Direct Progeny	Breed 2009 (1)	USMARC Bulls (2)				
Angus	104	622	0.21	0.05	0.00	12.77	0.00	0.00
Hereford	121	838	0.22	-0.04	-0.17	12.70	-0.06	-0.07
Red Angus	35	142	0.07	-0.16	-0.33	12.51	-0.26	-0.12
Shorthorn	41	152	0.07	0.01	0.20	12.87	0.10	0.24
South Devon	13	49	0.21	0.21	0.29	12.90	0.13	0.13
Santa Gertrudis	13	53	0.00	-0.03	-0.26	12.38	-0.39	-0.18
Braunvieh	21	139	0.10	0.02	0.89	13.58	0.81	0.92
Charolais	36	158	0.18	0.09	0.91	13.61	0.84	0.87
Chiangus	14	58	0.02	0.07	0.60	13.16	0.40	0.59
Limousin	51	302	0.49	0.27	1.27	14.10	1.34	1.06
Maine Anjou	31	138	0.15	0.15	1.05	13.66	0.90	0.96
Salers	40	133	0.03	0.03	0.79	13.40	0.63	0.81
Simmental	59	325	0.10	-0.05	0.85	13.61	0.84	0.95

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 12.61 in^2) with b = 1.00

(5) = (4) – (4, Angus)

(6) = (5) – (5, Angus) – [(1) – (1, Angus)]

[a]The breed difference estimates represent half the differences that would be expected between purebreds of the two breeds.

Table 7. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2009 base and factors to adjust within breed EPD to an Angus equivalent – FAT THICKNESS (in)

	Number		Ave. Base EPD		Breed Soln	BY 2009	BY 2009	Factor to
			Breed	USMARC	at USMARC	Sire Breed	Sire Breed	adjust EPD
	AI	Direct	2009	Bulls	(vs Ang)	Average	Difference[a]	To Angus
Breed	Sires	Progeny	(1)	(2)	(3)	(4)	(5)	(6)
Angus	104	622	0.012	0.002	0.000	0.578	0.000	0.000
Hereford	121	838	0.002	-0.003	-0.056	0.517	-0.061	-0.051
Red Angus	35	142	-0.034	-0.010	-0.050	0.494	-0.084	-0.038
Shorthorn	41	152	-0.010	0.000	-0.153	0.405	-0.173	-0.151
South Devon	13	49	0.010	0.008	-0.107	0.463	-0.115	-0.113
Santa Gertrudis	13	53	0.000	0.002	-0.146	0.420	-0.158	-0.146
Braunvieh	21	139	0.115	-0.012	-0.185	0.510	-0.068	-0.171
Charolais	36	158	-0.001	-0.001	-0.225	0.343	-0.235	-0.222
Chiangus	14	58	0.010	0.009	-0.165	0.404	-0.174	-0.172
Maine Anjou	31	138	0.000	-0.016	-0.226	0.358	-0.221	-0.209
Salers	40	133	0.000	-0.004	-0.223	0.349	-0.229	-0.217
Simmental	59	325	0.015	0.011	-0.210	0.363	-0.215	-0.218

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 0.568 in) with b = 1.00

(5) = (4) – (4, Angus)

(6) = (5) – (5, Angus) – [(1) – (1, Angus)]

[a]The breed difference estimates represent half the differences that would be expected between purebreds of the two breeds.

Table 8. Mean weighted[a] accuracies for birth weight (BWT), weaning weight (WWT), yearling weight (YWT), maternal weaning weight (MWWT), milk (MILK), marbling (MAR), ribeye area (REA), and fat thickness (FAT) for bulls used at USMARC

Breed	BWT	WWT	YWT	MILK	MAR	REA	FAT
Angus	0.78	0.75	0.69	0.66	0.50	0.49	0.47
Hereford	0.63	0.59	0.59	0.53	0.23	0.37	0.27
Red Angus	0.91	0.90	0.90	0.88	0.70	0.68	0.79
Shorthorn	0.80	0.79	0.73	0.76	0.61	0.59	0.54
South Devon	0.37	0.41	0.37	0.44	0.02	0.05	0.05
Beefmaster	0.86	0.89	0.86	0.75			
Brahman	0.65	0.66	0.59	0.57			
Brangus	0.87	0.81	0.79	0.68			
Santa Gertrudis	0.87	0.84	0.77		0.32	0.52	0.44
Braunvieh	0.85	0.86	0.83	0.79	0.46	0.28	0.48
Charolais	0.78	0.72	0.62	0.63	0.47	0.50	0.44
Chiangus	0.82	0.79	0.79		0.54	0.53	0.58
Gelbvieh	0.81	0.75	0.61	0.63			
Limousin	0.92	0.89	0.83	0.85	0.73	0.73	
Maine Anjou	0.77	0.76	0.76	0.75	0.35	0.34	0.35
Salers	0.83	0.82	0.76	0.82	0.21	0.26	0.29
Simmental	0.94	0.94	0.94	0.93	0.80	0.80	0.80
Tarentaise	0.96	0.95	0.95	0.94			

[a]Weighted by relationship to phenotyped animals at USMARC for BWT, WWT, YWT, MAR, REA, and FAT and by relationship to daughters with phenotyped progeny MILK.

Table 9. Estimates of variance components (lb^2) for birth weight (BWT), weaning weight (WWT), yearling weight (YWT), and maternal weaning weight (MWWT) and for marbling (MAR; marbling score units^2), ribeye area (REA; in^4), and fat thickness (FAT; in^2) from mixed model analyses

		Direct	
Analysis	BWT	WWT[a]	YWT
Direct			
Animal within breed (19 breeds)	70.58	477.83	3576.92
Maternal genetic within breed (17 breeds)		431.22	
Maternal permanent environment		681.53	
Residual	51.40	1207.02	4166.21
Carcass Direct	MAR	REA	FAT
Animal within breed (12-13 breeds)	0.255	0.636	0.0098
Residual	0.318	0.729	0.0148

[a]Direct maternal covariance for weaning weight was -88.59 lb^2

Table 10. Pooled and within-breed regression coefficients (lb/lb) for weights at birth (BWT), 205 days (WWT), and 365 days (YWT) of F_1 progeny and for calf weights (205 d) of F_1 dams (MILK) on sire expected progeny difference and by sire breed

	BWT	WWT	YWT	MILK
Pooled	1.15 ± 0.04	0.86 ± 0.04	1.04 ± 0.04	1.17 ± 0.09
Sire breed				
Angus	1.04 ± 0.10	0.83 ± 0.08	1.21 ± 0.08	1.14 ± 0.16
Hereford	1.18 ± 0.07	0.76 ± 0.05	1.03 ± 0.06	1.08 ± 0.16
Red Angus	1.06 ± 0.15	0.72 ± 0.16	0.56 ± 0.18	1.59 ± 0.34
Shorthorn	0.69 ± 0.28	0.79 ± 0.24	0.81 ± 0.29	0.95 ± 0.93
South Devon	-0.28 ± 0.64	0.02 ± 0.56	0.01 ± 0.47	-0.22 ± 1.54
Beefmaster	2.01 ± 0.45	1.19 ± 0.31	1.07 ± 0.49	3.94 ± 0.72
Brahman	2.18 ± 0.22	1.02 ± 0.21	1.21 ± 0.24	0.34 ± 0.51
Brangus	1.71 ± 0.32	0.45 ± 0.31	0.79 ± 0.43	0.45 ± 0.77
Santa Gertrudis	5.70 ± 1.29	1.44 ± 0.39	-0.02 ± 0.44	
Braunvieh	1.12 ± 0.30	1.39 ± 0.31	1.45 ± 0.39	2.99 ± 1.06
Charolais	1.09 ± 0.13	0.95 ± 0.12	0.77 ± 0.13	1.16 ± 0.30
Chiangus	1.91 ± 0.41	0.73 ± 0.35	0.64 ± 0.49	
Gelbvieh	1.00 ± 0.14	0.96 ± 0.17	1.13 ± 0.17	1.32 ± 0.46
Limousin	0.85 ± 0.11	0.98 ± 0.10	1.14 ± 0.13	1.45 ± 0.29
Maine Anjou	1.51 ± 0.27	0.56 ± 0.27	0.59 ± 0.35	1.07 ± 0.52
Salers	1.32 ± 0.28	0.91 ± 0.34	0.46 ± 0.32	1.75 ± 0.51
Simmental	1.16 ± 0.17	1.52 ± 0.15	1.34 ± 0.14	0.75 ± 0.39
Tarentaise	1.51 ± 1.36	0.70 ± 0.61	1.49 ± 0.82	1.00 ± 0.93

Table 11. Pooled and within-breed regression coefficients marbling (MAR; score/score), ribeye area (REA; in^2/in^2), and fat thickness (FAT; in/in) of F_1 progeny on sire expected progeny difference and by sire breed

	MAR	REA	FAT
Pooled	0.62 ± 0.06	0.98 ± 0.08	1.24 ± 0.11
Sire breed			
Angus	0.97 ± 0.11	0.94 ± 0.20	1.42 ± 0.18
Hereford	0.43 ± 0.19	0.58 ± 0.16	0.95 ± 0.21
Red Angus	1.06 ± 0.23	1.61 ± 0.33	0.85 ± 0.53
Shorthorn	1.81 ± 0.36	0.79 ± 0.68	2.33 ± 0.59
South Devon	-0.29 ± 0.62	1.66 ± 3.17	5.53 ± 4.58
Santa Gertrudis	-0.95 ± 1.64	0.92 ± 0.66	1.29 ± 0.73
Braunvieh	4.35 ± 1.68	1.32 ± 0.71	0.15 ± 0.39
Charolais	1.03 ± 0.32	1.58 ± 0.33	1.93 ± 0.59
Chiangus	0.65 ± 0.28	-0.06 ± 0.54	-0.76 ± 0.93
Limousin	1.18 ± 0.43	1.43 ± 0.21	
Maine Anjou	0.49 ± 0.83	-0.74 ± 0.65	1.34 ± 0.83
Salers	0.03 ± 0.10	3.20 ± 0.91	1.03 ± 0.93
Simmental	0.56 ± 0.18	0.59 ± 0.19	1.83 ± 0.45