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ACROSS-BREED EPD TABLES FOR THE YEAR 2009 ADJUSTED TO BREED DIFFERENCES FOR BIRTH YEAR OF 2007

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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 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 2009 EPD (with the exception of Tarentaise, for which the most recent EPD are Spring 2006). 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 2007. Any differences in the samples of sires representing the 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 2007) and out of dams of a third, unrelated breed.

Introduction

This report is the year 2009 update of estimates of sire breed means from data of the Germplasm Evaluation (GPE) project at USMARC adjusted to a year 2007 base using EPD from the most recent national cattle evaluations. Factors to adjust EPD of 18 breeds to a common birth year of 2007 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).

In addition, there was a significant procedural and a few data changes from the 2007 update (Kuehn et al., 2007):

The most significant change this year related to the model used to estimate breed effect differences. The USMARC GPE program is in the process of changing to more fully meet the needs of the beef industry. It includes objectives in genomics, predicting maternal and direct breed effects, estimation of breed specific heterosis, and partitioning breed effects from heterosis. As part of this change, purebred herds from 16 of the 18 breeds involved in the across-breed EPD process will be established, primarily by grading up through artificial insemination. The pedigree structure from both the grade up process and from the eventual GPE program will no longer fit the traditional sire model used in the across-breed EPD process to estimate breed of sire differences in the past. Therefore an animal model approach has been applied to estimate breed differences at USMARC. Unlike the sire model approach used in previous updates, this approach also allows progeny of F1 dams/sires to contribute to the estimation of breed of sire differences.

Part of the transition of the GPE project involves continuous sampling of the 16 breeds that register the most cattle and have national genetic evaluations for beef production traits. The first progeny of this new sampling were born in Fall 2007. This report includes progeny for 7 of these breeds born in Fall 2007 (BWT, WWT, and YWT records) and progeny for 14 of these breeds born in Spring 2008 and Fall 2008 (BWT and WWT records). New progeny of Beefmaster and Brangus will be born beginning in Fall 2009. Progeny of these 16 breeds should continue to accrue at the rate of approximately 50 per breed per year for the next several years. This transition of the GPE design also includes fall calving as well as spring; that will eventually decrease the disparity between YWT and WWT of the Brahman(-influenced) breeds.

Records from USMARC for birth, weaning, and yearling weight were added for several breeds (all except Brangus, Beefmaster, South Devon, and Tarentaise) from a new sampling of sires for the new GPE program. These additional data caused some significant small changes in the breed of sire solutions for these breeds relative to the other breeds in the analysis, especially for breeds that have not been sampled in GPE for over 25 yr. Maternal records continued to be added this year for Hereford, Angus, Simmental, Limousin, Charolais, Gelbvieh, Red Angus, Brangus and Beefmaster.

The across-breed table adjustments apply **only** to EPD for most recent (spring, 2008 in all but Tarentaise that were last evaluated in 2006) 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.

Materials and Methods

All calculations were as outlined in the 2002 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, 2008). 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

To accommodate the changing GPE structure, 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 (174), 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 (210) 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.

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 only the first generation of progeny from AI sires. Models included the same fixed effects described previously as well as a fixed effect of dam line. Dam was fitted as a random effect. Analysis of the MILK EPD was performed on daughters of the AI sires. These maternal effects models also included covariates of the sire's weaning weight EPD and fixed effects of the calving sire breed. Pooled regression coefficients, and regression coefficients by sire breed, and by sex of calf 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 genetic group (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 genetic group 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:

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

For weaning weight, the breed of sire solution for breed i adjusted for genetic trend on a USMARC scale, $M_{USMARC,i}$, is also calculated for use in MILK factor derivation:

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

where,

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

EPD(i)_{YY} is the average within-breed 2009 EPD for breed i for animals born in the base year (YY, which is two years before the update; e.g., YY = 2007 for the 2009 update),

$EPD(i)_{USMARC}$ is the weighted (by total relationship of descendants with records at USMARC) average of 2009 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 2008: 1.12, 0.87, 1.14, and 1.15 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 1.39 lb, 14.20 lb, 16.31 lb, 0.065 marbling score units (i.e. 4.00 = Sl^{00}, 5.00 = Sm^{00}), 0.24 in^2, and 0.046 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 19.33 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 and the adjustments to the breed of sire effects to a year 2007 base. 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).

Column 5 of each table represents the best estimates of sire breed differences for calves born in 2007 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 2007) of two different breeds and out of dams of a third, unrelated breed.

Breed differences and adjustments for MAR, REA, and FAT (Tables 5-7) are being reported for the second time this year. The number of breeds has increased from 8 last year to 11. Because of changes in the use of the regression coefficient (1.00 rather than the coefficient predicted from the data, there are no comparisons available to previous analyses. General trends are discussed in the individual trait sections. In future analyses, these traits are the most likely to change substantially.

In each table, breed of sire differences were added to the raw Angus mean (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 birth weight for a Gelbvieh bull is +2.0 (which is above the year 2007 average of 1.3 for Gelbvieh) and for a Hereford bull is also +2.0 (which is below the year 2007 average of 3.5 for Herefords). The across-breed adjustment factors in the last column of Table 1 are 2.9 for Hereford and 4.5 for Gelbvieh. Then the adjusted EPD for the Gelbvieh bull is 4.5 + 2.0 = 6.5 and for the Hereford bull is 2.9 + 2.0 = 4.9. The expected birth weight difference when both are mated to another breed of cow, e.g., Angus, would be 6.5 – 4.9 = 1.6 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, while -0.6 lb of the difference is due to the breed difference.

Birth Weight

The range in estimated breed of sire differences for BWT ranged from 1.0 lb for Red Angus to 8.1 lb for Charolais and 10.8 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. With the changes in modeling breed effects to include data beyond the initial cross generation as well as additional data from use of sire breeds in GPE that hadn't been sampled in over 20 yr, some breed differences changed by as much as 2.0 lb (Brangus) from those reported by Kuehn et al. (2008). Changes in breed of sire differences from Angus were 1.0 lb or less for 10 of the 15 non-Angus breeds summarized last year.

Weaning Weight

Breed effects on weaning weight remained fairly similar to Angus for most breeds—10 of the 17 sire breed differences were within 10 lb of Angus. Weaning weight sire breed differences tended to be lighter relative to Angus compared to Kuehn et al. (2008); the largest changes (>5 lb) in breed of sire difference relative to Angus were for Shorthorn, Brangus, Braunvieh, Maine Anjou, and Salers. Most of the large changes relative to Kuehn et al. (2008) can be attributed to larger numbers of progeny born in the sire group (e.g., Shorthorn, Braunvieh, Maine Anjou, and Salers). The average Brangus sire breed effect was predicted to be 8.8 lb lighter than in Kuehn et al. (2008) relative to Angus. Because Brangus added no new records from use of purebred sires in the GPE program, part of this difference is attributable to the inclusion of advanced generations (e.g., 1/4 Brangus) of progeny in the animal model analysis and the remainder to the increase of Angus relative to other breeds.

Yearling Weight

Several breeds (8 of 15) of sires were predicted to be heavier relative to Angus compared to the 2008 report. Of these Gelbvieh, Maine Anjou, and Salers had the highest gains (5-7 lb). However, almost all of the sire breeds were still lighter on average relative to Angus (as much as 65.8 lb for Braunvieh). Like weaning weight, the Brangus sire breed effect decreased by a substantial amount (11.2 lb) due to the change in modeling to include advanced progeny generations. Some decreases relative to Angus can be attributed to their continued genetic trend; the breed average EPD for Angus increased by 3.5 lb from 76.5 lb to 80.0 lb. Increased yearling weight seems to remain a priority for Angus breeders as Angus-sired calves were predicted to have heavier yearling weights than 15 (all but Charolais and Salers) other breeds.

Maternal Milk

The changes from last year for milk for the current base year (Table 4, column 5) were generally small even though these effects were now estimated from a maternal effects model for weaning weight rather than from a breed of maternal grandsire model. Five breeds of sire (Shorthorn, Beefmaster, Brangus, Braunvieh, and Maine Anjou) changed positively relative to Angus by over 4 lb; other differences relative to Kuehn et al. (2008) were minor. 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 Shorthorn and Red Angus being the most similar (~0.25 score units lower). In general, Continental breeds were estimated to be a 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. Braunvieh, Salers and Charolais were intermediate between the rest of the Continental breeds and the British breeds.

Fat Thickness

British breeds had 0.1 to 0.2 in more fat at slaughter than Continental breeds (Table 7, Column 5). Red Angus and Hereford were slightly leaner than Angus while Shorthorn and South Devon were considerably leaner. Charolais were predicted to be the leanest breed among the 10 breeds analyzed for carcass traits. Limousin was not included in the FAT analysis because they do not report an EPD for FAT.

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, 0.16, 0.47, and 0.16, respectively. Heritability estimates for MAR, REA, and FAT were 0.42, 0.48, 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 1.12 for BWT, 0.87 for WWT, and 1.14 for YWT were used to adjust breed of sire solutions to the base year of 2007. 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 16 breeds.

The regression coefficient for female progeny on sire EPD for YWT was 1.02 compared to 1.25 for steers and 1.14 for bulls. These differences might be expected due to scaling because postweaning average daily gains for heifers at USMARC have been significantly less than those for steers. The heifers were fed relatively high roughage diets to support average daily gains of 1.6 lb per day while the steers were fed relatively high energy growing and finishing diets supporting average daily gains of about 3.4 lb per day. This result may imply that heifers at USMARC are treated in a similar fashion to bulls and heifers in herds contributing to the national genetic evaluations. Bulls are likely treated at an intermediate level.

The coefficients of regression of records of grandprogeny on MGS EPD for WWT and MILK are shown in Table 11. Several sire (MGS) breeds have regression coefficients considerably different from the theoretical expected values of 0.50 for WWT and 1.00 for MILK. Standard errors, however, for the regression coefficients by breed are large except for Angus and Hereford. The pooled regression coefficients of 0.55 for MWWT and 1.15 for MILK are reasonably close to the expected regression coefficients of 0.50 and 1.00.

Regression coefficients derived from regression of USMARC steer progeny records on sire EPD for MAR, REA, and FAT are shown in Table 12. 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 quite high. Each coefficient deviates from the expected value of 1.00 more than the growth trait coefficients. Therefore, the theoretical estimate of 1.00 was used to derive breed of sire differences and EPD adjustment factors. The pooled regression estimates caused USMARC differences to be larger on an industry scale for MAR and smaller on an industry scale for REA and 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 2007 base and factors to adjust within breed EPD to an Angus equivalent – BIRTH WEIGHT (lb)

Breed	Number Sires	Number Progeny	Ave. Base EPD Breed 2007 (1)	Ave. Base EPD USMARC Bulls (2)	Breed Soln at USMARC (vs Ang) (3)	BY 2007 Sire Breed Average (4)	BY 2007 Sire Breed Difference (5)	Factor to adjust EPD To Angus (6)
Angus	114	1506	2.2	1.8	0.0	84.7	0.0	0.0
Hereford	121	1940	3.5	2.4	3.9	88.9	4.2	2.9
Red Angus	33	397	0.3	-1.1	0.0	85.7	1.0	2.9
Shorthorn	41	272	2.2	1.3	6.4	90.8	6.1	6.1
South Devon	15	153	2.6	2.4	5.7	89.6	4.9	4.5
Beefmaster	22	222	0.5	1.0	7.8	90.7	6.0	7.7
Brahman	54	735	1.8	0.3	10.9	95.5	10.8	11.2
Brangus	21	215	0.6	0.9	4.3	87.8	3.1	4.7
Santa Gertrudis	13	92	0.5	1.1	8.3	91.1	6.4	8.1
Braunvieh	18	249	-0.2	0.1	6.5	89.8	5.1	7.5
Charolais	83	818	0.6	0.3	9.2	92.8	8.1	9.7
Chiangus	13	97	1.2	2.6	5.6	87.8	3.1	4.1
Gelbvieh	60	765	1.3	1.0	4.2	88.3	3.6	4.5
Limousin	49	812	1.7	0.8	3.6	88.4	3.7	4.2
Maine Anjou	31	291	1.9	4.5	9.1	89.9	5.2	5.5
Salers	43	272	0.9	1.7	3.7	86.8	2.1	3.4
Simmental	54	775	1.3	2.2	6.6	89.3	4.6	5.5
Tarentaise	7	199	1.5	1.7	2.7	86.5	1.8	2.5

Calculations:
(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 84.7 lb) with b = 1.12
(5) = (4) – (4, Angus)
(6) = (5) – (5, Angus) – [(1) – (1, Angus)]

Table 2. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2007 base and factors to adjust within breed EPD to an Angus equivalent – WEANING WEIGHT (lb)

Breed	Number Sires	Number Progeny	Ave. Base EPD Breed 2007 (1)	Ave. Base EPD USMARC Bulls (2)	Breed Soln at USMARC (vs Ang) (3)	BY 2007 Sire Breed Average (4)	BY 2007 Sire Breed Difference (5)	Factor to adjust EPD To Angus (6)
Angus	114	1383	43.5	25.0	0.0	525.6	0.0	0.0
Hereford	120	1830	41.0	26.0	-1.5	520.3	-5.3	-2.8
Red Angus	33	388	31.2	26.9	-3.0	507.9	-17.7	-5.4
Shorthorn	41	257	14.3	10.9	5.0	516.3	-9.3	19.9
South Devon	15	134	39.7	18.6	0.4	528.7	3.1	6.9
Beefmaster	22	215	7.3	13.8	28.6	533.7	8.0	44.2
Brahman	54	640	13.6	5.0	14.1	532.0	6.4	36.3
Brangus	21	208	21.9	22.1	16.5	525.9	0.3	21.9
Santa Gertrudis	13	90	4.0	10.5	2.3	503.3	-22.4	17.1
Braunvieh	18	236	0.9	4.5	0.7	504.4	-21.2	21.4
Charolais	82	730	23.3	10.9	20.8	543.6	18.0	38.2
Chiangus	13	89	44.2	45.7	0.9	506.7	-18.9	-19.6
Gelbvieh	60	719	41.0	33.1	8.5	524.8	-0.8	1.7
Limousin	49	739	42.6	27.7	-0.6	521.3	-4.3	-3.4
Maine Anjou	31	266	40.1	42.3	5.7	511.5	-14.1	-10.7
Salers	43	257	17.8	8.1	5.0	522.6	-3.0	22.7
Simmental	52	705	32.4	25.7	22.2	539.5	13.9	25.0
Tarentaise	7	191	4.0	-5.3	-0.5	515.8	-9.8	29.7

Calculations:
(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 507.1 lb) with b = 0.87
(5) = (4) – (4, Angus)
(6) = (5) – (5, Angus) – [(1) – (1, Angus)]

Table 3. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2007 base and factors to adjust within breed EPD to an Angus equivalent – YEARLING WEIGHT (lb)

Breed	Number		Ave. Base EPD		Breed Soln at USMARC (vs Ang)	BY 2007 Sire Breed Average	BY 2007 Sire Breed Difference	Factor to adjust EPD To Angus
	Sires	Progeny	Breed 2007 (1)	USMARC Bulls (2)	(3)	(4)	(5)	(6)
Angus	106	1298	80.0	47.0	0.0	907.8	0.0	0.0
Hereford	112	1717	68.0	43.5	-22.3	879.7	-28.1	-16.1
Red Angus	21	328	54.9	44.9	-7.4	878.3	-29.5	-4.4
Shorthorn	33	194	23.4	17.1	26.1	904.0	-3.8	52.8
South Devon	15	134	75.5	46.5	-2.2	901.8	-5.9	-1.4
Beefmaster	22	157	12.5	22.2	21.9	884.3	-23.5	44.0
Brahman	52	516	22.2	9.2	-40.6	852.1	-55.6	2.2
Brangus	21	152	40.2	39.5	14.0	887.8	-19.9	19.9
Braunvieh	12	170	1.5	10.1	-27.5	842.1	-65.7	12.8
Charolais	74	656	41.2	21.1	29.6	920.9	13.1	51.9
Gelbvieh	48	665	74.0	59.6	-0.1	889.2	-18.6	-12.6
Limousin	40	672	79.1	54.6	-24.0	878.3	-29.5	-28.6
Maine Anjou	25	219	79.1	85.8	18.2	884.1	-23.7	-22.8
Salers	36	197	29.6	7.8	14.9	909.6	1.9	52.3
Simmental	48	618	57.5	45.9	24.3	907.7	-0.1	22.4
Tarentaise	7	189	11.0	-4.6	-38.4	856.7	-51.1	17.9

Calculations:
(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 874.8 lb) with b = 1.14
(5) = (4) – (4, Angus)
(6) = (5) – (5, Angus) – [(1) – (1, Angus)]

Table 4. Breed of maternal grandsire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2007 base and factors to adjust within breed EPD to an Angus equivalent – MILK (lb)

Breed	Number Sires	Number Gpr	Number Progeny	Ave. Base EPD Breed 2007 (1)	Ave. Base EPD USMARC Bulls (2)	Breed Soln at USMARC (vs Ang) (3)	BY 2007 Sire Breed Average (4)	BY 2007 Sire Breed Difference (5)	Factor to adjust EPD To Angus (6)
Angus	104	2650	559	20.5	11.0	0.0	516.7	0.0	0.0
Hereford	108	3424	730	16.0	8.1	-23.4	494.6	-22.0	-17.5
Red Angus	21	508	98	16.1	13.3	-0.7	509.2	-7.4	-3.0
Shorthorn	22	264	69	2.5	5.2	20.0	521.8	5.1	23.1
South Devon	14	373	70	21.4	19.3	2.0	511.0	-5.6	-6.5
Beefmaster	20	220	51	2.0	-1.7	-11.6	500.8	-15.9	2.6
Brahman	44	1102	246	5.8	2.5	23.7	531.0	14.3	29.0
Brangus	19	204	43	7.3	2.3	-7.2	505.8	-10.8	2.4
Braunvieh	6	413	69	0.3	-0.8	21.7	527.0	10.4	30.6
Charolais	68	1265	243	6.5	3.5	-2.2	508.2	-8.4	5.6
Gelbvieh	47	1237	243	18.0	16.7	18.0	524.1	7.4	9.9
Limousin	40	1379	247	21.3	17.2	-9.2	503.3	-13.4	-14.2
Maine Anjou	17	529	87	20.0	24.4	14.5	515.4	-1.3	-0.8
Salers	25	361	88	8.4	10.9	15.0	517.7	1.0	13.1
Simmental	47	1370	245	4.2	8.4	12.8	514.0	-2.6	13.7
Tarentaise	6	367	80	1.0	4.6	18.2	519.3	2.7	22.2

Calculations:
(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 507.1 lb) with b = 1.15
(5) = (4) – (4, Angus)
(6) = (5) – (5, Angus) – [(1) – (1, Angus)]

Table 5. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2007 base and factors to adjust within breed EPD to an Angus equivalent – MARBLING (marbling score units[a])

	Number		Ave. Base EPD		Breed Soln at USMARC	BY 2007 Sire Breed	BY 2007 Sire Breed	Factor to adjust EPD
			Breed 2007	USMARC Bulls	(vs Ang)	Average	Difference	To Angus
Breed	Sires	Progeny	(1)	(2)	(3)	(4)	(5)	(6)
Angus	92	581	0.31	0.12	0.00	5.84	0.00	0.00
Hereford	82	441	0.03	-0.01	-0.48	5.21	-0.64	-0.36
Red Angus	20	97	0.06	0.16	0.03	5.58	-0.26	-0.01
Shorthorn	28	106	0.00	0.01	-0.05	5.59	-0.25	0.06
South Devon	7	34	0.26	0.23	-0.21	5.47	-0.37	-0.32
Braunvieh	9	58	0.01	-0.02	-0.39	5.28	-0.56	-0.26
Charolais	23	103	0.03	-0.05	-0.67	5.06	-0.78	-0.50
Limousin	39	256	0.00	-0.07	-0.99	4.73	-1.11	-0.80
Maine Anjou	21	104	0.21	0.16	-0.88	4.83	-1.02	-0.92
Salers	29	89	0.00	-0.20	-0.43	5.42	-0.42	-0.11
Simmental	47	275	0.13	0.07	-0.64	5.07	-0.78	-0.60

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

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 5.65) with b = 1.00

(5) = (4) – (4, Angus)

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

Table 6. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2007 base and factors to adjust within breed EPD to an Angus equivalent – RIBEYE AREA (in^2)

Breed	Number Sires	Number Progeny	Ave. Base EPD Breed 2007 (1)	Ave. Base EPD USMARC Bulls (2)	Breed Soln at USMARC (vs Ang) (3)	BY 2007 Sire Breed Average (4)	BY 2007 Sire Breed Difference (5)	Factor to adjust EPD To Angus (6)
Angus	92	582	0.15	0.02	0.00	12.14	0.00	0.00
Hereford	82	441	0.17	0.05	-0.22	11.92	-0.22	-0.24
Red Angus	20	97	0.05	-0.18	-0.40	11.83	-0.31	-0.21
Shorthorn	28	106	-0.02	-0.03	0.07	12.10	-0.05	0.12
South Devon	7	34	0.10	-0.04	0.33	12.49	0.34	0.39
Braunvieh	9	58	0.01	-0.01	0.76	12.79	0.64	0.78
Charolais	23	104	0.17	0.11	0.72	12.79	0.65	0.63
Limousin	39	256	0.40	0.29	1.21	13.33	1.18	0.93
Maine Anjou	21	104	0.16	0.08	1.13	13.22	1.08	1.07
Salers	29	89	0.02	0.02	0.78	12.79	0.65	0.78
Simmental	47	275	0.08	-0.08	0.82	12.99	0.85	0.92

Calculations:
(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 12.01 in^2) with b = 1.00
(5) = (4) – (4, Angus)
(6) = (5) – (5, Angus) – [(1) – (1, Angus)]

Table 7. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2007 base and factors to adjust within breed EPD to an Angus equivalent – FAT THICKNESS (in)

	Number		Ave. Base EPD		Breed Soln at USMARC	BY 2007 Sire Breed	BY 2007 Sire Breed	Factor to adjust EPD
			Breed 2007	USMARC Bulls	(vs Ang)	Average	Difference	To Angus
Breed	Sires	Progeny	(1)	(2)	(3)	(4)	(5)	(6)
Angus	92	582	0.011	0.000	0.000	0.549	0.000	0.000
Hereford	82	441	0.002	-0.001	-0.058	0.483	-0.066	-0.057
Red Angus	20	97	-0.001	-0.010	-0.055	0.492	-0.057	-0.045
Shorthorn	28	106	0.000	0.007	-0.126	0.405	-0.144	-0.133
South Devon	7	34	0.010	0.006	-0.125	0.417	-0.132	-0.131
Braunvieh	9	58	-0.003	-0.036	-0.184	0.386	-0.163	-0.149
Charolais	23	104	0.001	-0.003	-0.247	0.295	-0.254	-0.244
Maine Anjou	21	104	0.000	-0.008	-0.204	0.341	-0.208	-0.197
Salers	29	89	0.000	-0.004	-0.228	0.314	-0.235	-0.224
Simmental	46	274	0.010	0.028	-0.165	0.355	-0.194	-0.193

Calculations:
(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 0.538 in) with b = 1.00
(5) = (4) – (4, Angus)
(6) = (5) – (5, Angus) – [(1) – (1, Angus)]

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	0.76	0.73	0.67	0.64	0.48	0.47	0.44
Hereford	0.60	0.57	0.56	0.50	0.26	0.31	0.29
Red Angus	0.91	0.90	0.89	0.84	0.69	0.67	0.57
Shorthorn	0.79	0.78	0.71	0.74	0.61	0.60	0.62
South Devon	0.39	0.40	0.38	0.42	0.64	0.64	0.69
Beefmaster	0.72	0.80	0.69	0.72			
Brahman	0.52	0.52	0.45	0.48			
Brangus	0.83	0.81	0.69	0.72			
Santa Gertrudis	0.86	0.83	0.74				
Braunvieh	0.85	0.86	0.84	0.80	0.57	0.42	0.62
Charolais	0.76	0.69	0.60	0.58	0.46	0.49	0.43
Chiangus	0.82	0.78	0.83				
Gelbvieh	0.79	0.74	0.59	0.55			
Limousin	0.92	0.89	0.83	0.84	0.71	0.71	
Maine Anjou	0.75	0.75	0.74	0.73	0.35	0.35	0.36
Salers	0.79	0.79	0.72	0.79	0.17	0.23	0.25
Simmental	0.94	0.94	0.93	0.93	0.77	0.77	0.81
Tarentaise	0.95	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), maternal weaning weight (MWWT), marbling (MAR), ribeye area (REA), and fat thickness (FAT) from mixed model analyses

	Direct			Maternal
Analysis	BWT	WWT	YWT	WWT
Direct				
Animal within breed (19)	71.01	437.13	3586.76	
Residual	50.66		4019.01	
Maternal				
Animal within breed (17)		-53.92[a]		420.44
Permanent environment				671.75
Residual				1190.88

Carcass Direct	MAR	REA	FAT
Animal within breed (12)	0.240	0.703	0.0104
Residual	0.328	1.364	0.0263

[a]Direct maternal covariance for weaning weight

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

	BWT	WWT	YWT
Pooled	1.12 ± 0.04	0.87 ± 0.05	1.14 ± 0.05
Sire breed			
Angus	0.90 ± 0.10	0.88 ± 0.09	1.17 ± 0.08
Hereford	1.26 ± 0.08	0.83 ± 0.07	1.16 ± 0.07
Red Angus	1.00 ± 0.16	0.82 ± 0.29	0.99 ± 0.30
Shorthorn	0.76 ± 0.32	0.68 ± 0.30	1.11 ± 0.30
South Devon	0.79 ± 0.57	-0.05 ± 0.35	0.02 ± 0.39
Beefmaster	1.08 ± 0.53	1.66 ± 0.38	1.59 ± 0.46
Brahman	2.03 ± 0.21	0.80 ± 0.23	0.89 ± 0.24
Brangus	1.86 ± 0.37	0.75 ± 0.43	0.56 ± 0.40
Santa Gertrudis	6.03 ± 1.78	1.07 ± 0.50	-0.76 ± 0.76
Braunvieh	0.79 ± 0.39	0.89 ± 0.48	1.03 ± 0.60
Charolais	1.09 ± 0.13	0.98 ± 0.14	1.01 ± 0.13
Chiangus	1.57 ± 0.62	0.47 ± 0.42	-0.89 ± 1.03
Gelbvieh	0.94 ± 0.15	0.92 ± 0.22	1.34 ± 0.19
Limousin	0.91 ± 0.13	0.72 ± 0.14	1.11 ± 0.14
Maine Anjou	1.47 ± 0.33	0.17 ± 0.37	-0.06 ± 0.46
Salers	1.13 ± 0.29	0.81 ± 0.37	0.77 ± 0.39
Simmental	1.04 ± 0.19	1.38 ± 0.17	1.37 ± 0.15
Tarentaise	0.57 ± 0.88	0.68 ± 0.56	1.30 ± 0.60
Sex of calf			
Bulls	1.14 ± 0.05	0.88 ± 0.27	1.14 ± 0.37
Heifers	1.10 ± 0.06	0.90 ± 0.06	1.02 ± 0.06
Steers		0.83 ± 0.06	1.25 ± 0.05

Table 11. Pooled and within-breed (-sex) regression coefficients (lb/lb) for progeny performance on maternal grandsire EPD for weaning weight (MWWT) and milk (MILK) and by breed of maternal grandsire, breed of maternal grandam, and sex of calf

Type of regression	MWWT	MILK
Pooled	0.55 ± 0.07	1.15 ± 0.10
Breed of maternal grandsire		
Angus	0.42 ± 0.13	1.15 ± 0.19
Hereford	0.55 ± 0.10	1.14 ± 0.18
Red Angus	0.72 ± 0.40	1.95 ± 0.44
Shorthorn	0.43 ± 0.57	0.29 ± 0.98
South Devon	0.33 ± 0.42	-1.36 ± 1.37
Beefmaster	0.59 ± 0.60	3.24 ± 0.64
Brahman	0.72 ± 0.33	0.66 ± 0.57
Brangus	0.46 ± 0.80	0.94 ± 0.78
Braunvieh	0.78 ± 2.11	2.14 ± 2.21
Charolais	0.24 ± 0.18	1.26 ± 0.33
Gelbvieh	0.95 ± 0.33	1.19 ± 0.53
Limousin	1.13 ± 0.19	1.83 ± 0.36
Maine Anjou	-0.14 ± 0.60	0.57 ± 0.76
Salers	0.94 ± 0.53	2.19 ± 0.60
Simmental	0.85 ± 0.28	0.80 ± 0.58
Tarentaise	0.32 ± 1.10	0.95 ± 1.35
Sex of calf		
Heifers	0.53 ± 0.07	1.07 ± 0.10
Steers	0.58 ± 0.07	1.22 ± 0.10

Table 12. 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 and dam breed

	MAR	REA	FAT
Pooled	0.67 ± 0.08	1.28 ± 0.12	1.39 ± 0.15
Sire breed			
Angus	0.79 ± 0.14	1.25 ± 0.26	1.61 ± 0.24
Hereford	0.66 ± 0.24	0.92 ± 0.34	1.09 ± 0.26
Red Angus	1.07 ± 0.30	1.76 ± 0.55	2.90 ± 0.96
Shorthorn	1.92 ± 0.45	0.77 ± 0.78	3.32 ± 0.83
South Devon	0.48 ± 1.47	1.50 ± 2.23	-8.24 ± 5.42
Braunvieh	2.45 ± 1.96	-0.94 ± 1.74	-1.03 ± 1.04
Charolais	0.64 ± 0.49	1.87 ± 0.53	1.59 ± 1.35
Limousin	2.46 ± 0.56	1.25 ± 0.30	1.44 ± 0.49
Maine Anjou	-0.39 ± 1.02	-3.84 ± 2.23	-0.02 ± 1.95
Salers	0.03 ± 0.16	3.25 ± 1.32	-0.42 ± 1.66
Simmental	0.42 ± 0.24	1.22 ± 0.28	1.87 ± 0.68