ACROSS-BREED EPD TABLES FOR THE YEAR 2014 ADJUSTED TO BREED DIFFERENCES FOR BIRTH YEAR OF 2012

L. A. Kuehn[1] and R. M. Thallman[1]

[1]Roman L. Hruska U.S. Meat Animal Research Center, USDA-ARS, Clay Center, NE 68933

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 2014 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 2012. 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 (born in 2012) of two different breeds 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 2014 update of estimates of sire breed means from data of the Germplasm Evaluation (GPE) project at USMARC adjusted to a year 2012 basis using EPD from the most recent national cattle evaluations. The 2012 basis year is chosen because yearling records for weight and carcass traits should have been accounted for in EPDs for progeny born in 2012 in the Spring 2014 EPD national genetic evaluations. Factors to adjust Spring 2014 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 5-7 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, 2014) national cattle evaluations. Serious errors can occur if the table adjustments are used with earlier or later 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 2013 (Kuehn and Thallman, 2013):

New samplings of sires in the USMARC GPE program continued to increase progeny records for all of the breeds. The GPE program has entered a new phase in which more progeny are produced from breeds with higher numbers of registrations. Breeds with large increases in progeny numbers as a percentage of total progeny included South Devon and Tarentaise (especially for yearling weight) and Santa Gertrudis and Chiangus (especially for maternal milk). However, all of the breeds will continue to produce progeny in the project and sires continue to be sampled on a continuous basis for each of the 18 breeds in the across-breed EPD program. These additional progeny improve the accuracy of breed differences estimated at USMARC (column 3 in Tables 1-7) particularly for breeds with less data in previous GPE cycles (e.g., South Devon, Tarentaise, Santa Gertrudis, Chiangus).

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), Kuehn et al. (2007-2011), and Kuehn and Thallman (2012, 2013). 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 and different selection histories, 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 (255), 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 (265) 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. In addition, the regression coefficients by sire breed may reflect differences in genetic trends for different breeds. 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):

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

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,

$\text{EPD}(i)_{YY}$ is the average within-breed 2014 EPD for breed i for animals born in the base year (YY, which is two years before the update; e.g., YY = 2012 for the 2014 update),

$\text{EPD}(i)_{\text{USMARC}}$ is the weighted (by total relationship of descendants with records at USMARC) average of 2014 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 2014: 1.16, 0.84, 1.05, and 1.11 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 1.41 lb, 13.83 lb, 20.51 lb, -0.04 marbling score units (i.e. 4.00 = Sl^{00}, 5.00 = Sm^{00}), 0.26 in^2, and 0.035 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 9.78 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 2012 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 traits (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 2012 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 2012) 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 2009 through 2013 at USMARC (Column 4) to make these differences more interpretable to producers on scales they are accustomed to.

Figures 1-4 illustrate the relative genetic trends of most of the breeds involved (if they submitted trends) adjusted to a constant base using the adjustment factors in column 6 of Tables 1-7. These figures demonstrate the effect of selection over time on breed differences; breeders within each breed apply variable levels of selection toward each trait resulting in reranking of breeds for each trait over time. These figures and Column 5 of Tables 1-7 can be used to identify breeds with potential for complementarity in mating programs.

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 yearling weight for a Red Angus bull is +85.0 (which is above the birth year 2012 average of 83 for Red Angus) and for a Charolais bull is +37.0 (which is below the birth year 2012 average of 45.7 for Charolais). The across-breed adjustment factors in the last column of Table 3 are -29.9 for Red Angus and 40.9 for Charolais. Then the adjusted EPD for the Red Angus bull is 85.0 + (-29.9) = 55.1 and for the Charolais bull is 37.0 + (40.9) = 77.9. The expected yearling weight difference when both are mated to another breed of cow, e.g., Hereford, would be 55.1 – 77.9 = -22.8 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 deviated.

Birth Weight

The range in estimated breed of sire differences for BWT (Table 1, column 5) ranged from 1.1 lb for Red Angus to 7.5 lb for Charolais and 10.9 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 1.5 lb for all breeds relative to last year's update (Kuehn and Thallman, 2013).

Weaning Weight

All of the 17 breed differences (Table 2, column 5) were within 6 lb of the values reported by Kuehn and Thallman. (2013). Changes in breed effects for all 18 breeds seem to be stabilizing since continuous sampling started in 2007.

Yearling Weight

Breed of sire effects for yearling weight were also similar to Kuehn and Thallman (2013) in general. South Devon and Tarentaise had the first yearling weight records recorded in the GPE program; their breed differences relative to Angus were smaller than estimated from previous sampling in the 1970s. Angus continued to have the greatest rate of genetic change for yearling weight, causing most breed of sire differences relative to Angus to decrease at least slightly.

Maternal Milk

Changes to the maternal milk breed of sire differences (Table 4, column 5) were generally small. All changes were less than 6 lb difference from those reported in 2013. However, the breed solution estimates (Table 4, column 3) are expected to change the most in future updates as GPE heifers from each of the 18 breeds being continuously sampled are developed and bred. Chiangus and Santa Gertrudis estimates and factors for maternal milk are presented here for the first time. No females from newly sampled South Devon or Tarentaise sires have weaned progeny as of yet. We would expect their solutions to change the most in future reports.

Marbling, Ribeye Area, and Fat Thickness

Most changes to breed of sire differences were minor for each of these carcass traits. South Devon was predicted to have less marbling relative to Angus in comparison to Kuehn and Thallman (2013), likely due to new progeny carcass records from sires sampled in 2011. Adjustment factors for Brahman are reported for the first time in this update.

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. 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 0.57, 0.17, 0.44, and 0.15, respectively. Heritability estimates for MAR, REA, and FAT were 0.50, 0.48, and 0.43, 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 1.16 for BWT, 0.84 for WWT, and 1.05 for YWT were used to adjust breed of sire solutions to the base year of 2012. 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 at USMARC, especially steers and market heifers, 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 1.11 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 higher, though they have decreased from the previous year. While REA and FAT are both close to the theoretical estimate of 1.00, we continued to use the theoretical estimate of 1.00 to derive breed of sire differences and EPD adjustment factors. Pooled regression estimates for these two traits may be used in future updates.

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 were last reported in 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.

Table 1. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2012 base and factors to adjust within breed EPD to an Angus equivalent – BIRTH WEIGHT (lb)

Breed	Number: AI Sires	Number: Direct Progeny	Ave. Base EPD: Breed 2012 (1)	Ave. Base EPD: USMARC Bulls (2)	Breed Soln at USMARC (vs Ang) (3)	BY 2012 Sire Breed Average (4)	BY 2012 Sire Breed Difference[a] (5)	Factor to adjust EPD To Angus (6)
Angus	152	1936	1.8	1.8	0.0	87.0	0.0	0.0
Hereford	149	2318	3.5	2.3	3.7	91.3	4.4	2.7
Red Angus	49	682	-1.2	-2.1	0.2	88.0	1.1	4.1
Shorthorn	55	508	2.2	1.5	6.7	93.5	6.6	6.2
South Devon	25	195	2.6	2.1	4.2	91.1	4.1	3.3
Beefmaster	53	465	0.3	0.9	6.3	91.8	4.9	6.4
Brahman	56	682	1.7	0.5	11.2	97.9	10.9	11.0
Brangus	53	477	0.8	0.8	3.9	90.3	3.4	4.4
Santa Gertrudis	21	276	0.2	0.6	6.6	92.3	5.4	7.0
Braunvieh	30	454	2.8	4.5	5.7	90.2	3.3	2.3
Charolais	107	1126	0.5	0.2	8.3	94.4	7.5	8.8
Chiangus	24	288	3.7	3.5	4.5	91.1	4.1	2.2
Gelbvieh	79	1038	0.8	2.1	4.2	89.3	2.4	3.4
Limousin	67	1104	1.7	1.0	3.4	90.6	3.7	3.8
Maine Anjou	48	506	1.7	2.7	6.7	91.8	4.8	4.9
Salers	50	459	1.6	2.4	3.2	88.9	2.0	2.2
Simmental	85	1107	2.2	3.4	5.7	90.8	3.8	3.4
Tarentaise	17	245	1.9	2.1	2.5	88.9	2.0	1.9

Calculations:

(4) = (3) / b + [(1) – (2)] + (Recent Raw Angus Mean: 87.0 lb) with b = 1.16

(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 2012 base and factors to adjust within breed EPD to an Angus equivalent – WEANING WEIGHT (lb)

Breed	Number		Ave. Base EPD		Breed Soln at USMARC (vs Ang) (3)	BY 2012 Sire Breed Average (4)	BY 2012 Sire Breed Difference[a] (5)	Factor to adjust EPD To Angus (6)
	AI Sires	Direct Progeny	Breed 2012 (1)	USMARC Bulls (2)				
Angus	152	1784	48.0	27.1	0.0	574.3	0.0	0.0
Hereford	147	2144	46.5	27.7	-3.1	568.6	-5.7	-4.2
Red Angus	49	656	54.0	48.0	-1.1	558.1	-16.1	-22.1
Shorthorn	55	478	15.2	15.0	-1.9	551.3	-22.9	9.9
South Devon	25	176	43.0	26.1	-5.2	564.1	-10.2	-5.2
Beefmaster	53	442	10.0	12.9	19.3	573.4	-0.8	37.2
Brahman	56	591	16.0	6.1	19.9	587.0	12.8	44.8
Brangus	53	456	24.3	21.7	8.3	565.9	-8.3	15.4
Santa Gertrudis	21	263	3.5	5.0	15.5	570.4	-3.9	40.6
Braunvieh	30	422	39.3	47.3	-2.8	542.1	-32.1	-23.4
Charolais	106	1022	25.6	14.5	21.2	589.8	15.5	37.9
Chiangus	24	256	38.4	40.7	-5.0	545.2	-29.1	-19.5
Gelbvieh	79	974	64.5	57.2	8.9	571.4	-2.9	-19.4
Limousin	66	1015	45.9	29.7	1.5	571.4	-2.9	-0.8
Maine Anjou	48	470	38.8	38.6	-6.3	546.1	-28.2	-19.0
Salers	50	436	41.0	33.8	1.3	562.1	-12.1	-5.1
Simmental	84	1009	64.2	57.2	19.9	584.1	9.8	-6.4
Tarentaise	17	237	16.0	-2.6	0.9	573.0	-1.3	30.7

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 553.4 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 2012 base and factors to adjust within breed EPD to an Angus equivalent – YEARLING WEIGHT (lb)

Breed	Number: AI Sires	Number: Direct Progeny	Ave. Base EPD: Breed 2012 (1)	Ave. Base EPD: USMARC Bulls (2)	Breed Soln at USMARC (vs Ang) (3)	BY 2012 Sire Breed Average (4)	BY 2012 Sire Breed Difference[a] (5)	Factor to adjust EPD To Angus (6)
Angus	135	1598	86.0	48.3	0.0	1051.3	0.0	0.0
Hereford	140	1997	75.5	46.4	-26.7	1017.2	-34.1	-23.6
Red Angus	47	595	83.0	69.9	-8.7	1018.4	-32.9	-29.9
Shorthorn	52	429	24.9	23.7	3.3	1018.0	-33.3	27.8
South Devon	25	175	80.0	55.1	-18.4	1020.9	-30.4	-24.4
Beefmaster	49	337	14.0	19.1	4.3	1012.6	-38.7	33.3
Brahman	56	534	25.0	10.9	-28.7	1000.4	-50.9	10.1
Brangus	48	333	43.5	40.4	-2.9	1014.0	-37.3	5.2
Santa Gertrudis	21	237	5.2	9.5	5.0	1014.0	-37.3	43.5
Braunvieh	30	399	61.9	73.6	-23.5	979.6	-71.8	-47.7
Charolais	101	930	45.7	28.2	21.9	1052.0	0.6	40.9
Chiangus	24	222	70.7	71.1	-24.0	990.4	-61.0	-45.6
Gelbvieh	75	920	93.2	73.7	0.6	1033.6	-17.7	-24.9
Limousin	64	954	83.3	59.2	-29.1	1009.9	-41.4	-38.7
Maine Anjou	44	429	77.8	78.5	-11.8	1001.7	-49.7	-41.5
Salers	50	404	80.0	64.6	-8.7	1020.8	-30.6	-24.6
Simmental	78	891	93.2	83.0	22.2	1044.9	-6.4	-13.6
Tarentaise	17	234	28.6	1.1	-38.7	1004.2	-47.1	10.3

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 1013.6 lb) with b = 1.05

(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 2012 base and factors to adjust within breed EPD to an Angus equivalent – MILK (lb)

	Number			Ave. Base EPD		Breed Soln	BY 2012	BY 2012	Factor to
Breed	AI Sires	Direct Gpr	Direct Progeny	Breed 2012 (1)	USMARC Bulls (2)	at USMARC (vs Ang) (3)	Sire Breed Average (4)	Sire Breed Difference[a] (5)	adjust EPD To Angus (6)
Angus	127	2915	659	24.0	14.1	0.0	563.3	0.0	0.0
Hereford	129	3593	841	18.8	10.0	-24.2	540.4	-22.9	-17.7
Red Angus	40	855	233	18.0	14.5	2.1	558.8	-4.5	1.5
Shorthorn	41	409	156	2.2	4.0	12.8	563.2	-0.1	21.7
South Devon	14	347	69	24.0	19.1	7.0	564.6	1.3	1.3
Beefmaster	34	336	101	2.0	-0.1	-8.7	547.7	-15.6	6.4
Brahman	53	807	241	6.0	6.9	18.6	569.2	5.9	23.9
Brangus	35	313	80	11.1	5.7	-7.0	552.5	-10.8	2.1
Santa Gertrudis	21	163	89	0.2	-2.2	-3.7	552.5	-10.8	13.0
Braunvieh	26	637	158	33.0	33.5	23.6	574.2	10.9	1.9
Charolais	87	1561	385	7.7	5.5	-2.1	553.7	-9.6	6.7
Chiangus	21	161	82	10.2	5.3	-8.7	550.4	-12.8	1.0
Gelbvieh	69	1509	359	28.0	30.6	21.9	570.5	7.2	3.2
Limousin	60	1709	394	22.6	19.0	-2.4	554.9	-8.4	-7.0
Maine Anjou	36	610	161	20.2	20.8	-0.6	552.3	-10.9	-7.1
Salers	45	504	172	19.0	19.9	10.4	561.9	-1.4	3.6
Simmental	65	1663	387	23.7	27.2	15.0	563.5	0.2	0.5
Tarentaise	6	341	78	0.6	5.3	18.1	565.0	1.7	25.1

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 553.4 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 5. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2012 base and factors to adjust within breed EPD to an Angus equivalent – MARBLING (marbling score units[a])

Breed	Number AI Sires	Number Direct Progeny	Ave. Base EPD Breed 2012 (1)	Ave. Base EPD USMARC Bulls (2)	Breed Soln at USMARC (vs Ang) (3)	BY 2012 Sire Breed Average (4)	BY 2012 Sire Breed Difference[b] (5)	Factor to adjust EPD To Angus (6)
Angus	118	714	0.50	0.19	0.00	6.10	0.00	0.00
Hereford	137	928	0.05	-0.01	-0.51	5.34	-0.76	-0.31
Red Angus	46	220	0.41	0.46	-0.07	5.67	-0.43	-0.34
Shorthorn	51	228	0.03	0.02	-0.36	5.44	-0.66	-0.19
South Devon	22	68	0.40	-0.07	-0.37	5.89	-0.21	-0.11
Brahman	54	222	0.00	-0.01	-1.04	4.76	-1.35	-0.85
Santa Gertrudis	21	113	-0.01	-0.02	-0.87	4.93	-1.17	-0.67
Charolais	46	239	0.02	-0.03	-0.65	5.20	-0.91	-0.43
Chiangus	24	107	0.22	0.20	-0.42	5.39	-0.71	-0.43
Gelbvieh	71	400	0.01	-0.24	-0.77	5.27	-0.84	-0.35
Limousin	59	383	-0.01	-0.07	-0.97	4.88	-1.22	-0.71
Maine Anjou	44	220	0.20	0.12	-0.78	5.09	-1.02	-0.72
Salers	46	193	0.20	-0.39	-0.67	5.71	-0.40	-0.10
Simmental	74	423	0.13	-0.03	-0.63	5.32	-0.78	-0.41

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 5.79) 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 2012 base and factors to adjust within breed EPD to an Angus equivalent – RIBEYE AREA (in^2)

	Number		Ave. Base EPD		Breed Soln at USMARC	BY 2012 Sire Breed	BY 2012 Sire Breed	Factor to adjust EPD
Breed	AI Sires	Direct Progeny	Breed 2012 (1)	USMARC Bulls (2)	(vs Ang) (3)	Average (4)	Difference[a] (5)	To Angus (6)
Angus	118	715	0.48	0.08	0.00	13.19	0.00	0.00
Hereford	137	928	0.28	-0.04	-0.20	12.92	-0.28	-0.08
Red Angus	46	220	0.14	-0.13	-0.23	12.83	-0.36	-0.02
Shorthorn	51	228	-0.02	0.01	0.16	12.92	-0.27	0.23
South Devon	22	68	0.23	0.21	0.37	13.18	-0.02	0.23
Brahman	54	227	0.08	0.04	-0.12	12.72	-0.48	-0.08
Santa Gertrudis	21	114	0.05	0.01	-0.16	12.68	-0.52	-0.09
Charolais	46	240	0.21	0.07	1.03	13.97	0.77	1.04
Chiangus	24	108	0.08	0.04	0.42	13.25	0.06	0.46
Gelbvieh	71	402	0.42	0.33	0.92	13.81	0.61	0.67
Limousin	59	384	0.55	0.31	1.31	14.35	1.15	1.08
Maine Anjou	44	220	0.17	0.14	1.00	13.81	0.62	0.93
Salers	46	194	0.03	0.03	0.78	13.56	0.37	0.82
Simmental	74	424	0.76	0.52	0.91	13.93	0.74	0.46

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 12.79 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 2012 base and factors to adjust within breed EPD to an Angus equivalent – FAT THICKNESS (in)

Breed	Number		Ave. Base EPD		Breed Soln at USMARC	BY 2012 Sire Breed	BY 2012 Sire Breed	Factor to adjust EPD
	AI Sires	Direct Progeny	Breed 2012 (1)	USMARC Bulls (2)	(vs Ang) (3)	Average (4)	Difference[a] (5)	To Angus (6)
Angus	118	715	0.010	0.001	0.000	0.639	0.000	0.000
Hereford	137	927	0.002	-0.004	-0.056	0.580	-0.059	-0.051
Red Angus	46	219	-0.003	-0.008	-0.037	0.598	-0.040	-0.027
Shorthorn	51	228	-0.009	-0.008	-0.144	0.485	-0.154	-0.135
South Devon	22	68	0.010	0.008	-0.128	0.503	-0.135	-0.135
Brahman	54	227	0.010	-0.003	-0.154	0.489	-0.150	-0.150
Santa Gertrudis	21	114	0.002	0.006	-0.098	0.527	-0.111	-0.103
Charolais	46	239	0.001	0.002	-0.213	0.416	-0.222	-0.213
Chiangus	24	107	0.011	0.011	-0.136	0.494	-0.144	-0.145
Gelbvieh	70	400	-0.050	-0.078	-0.211	0.447	-0.191	-0.131
Maine Anjou	44	220	-0.003	0.000	-0.225	0.401	-0.237	-0.224
Salers	46	194	0.000	-0.007	-0.215	0.422	-0.216	-0.206
Simmental	74	424	-0.060	-0.051	-0.201	0.420	-0.219	-0.149

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 0. 630 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	0.80	0.78	0.72	0.73	0.53	0.52	0.51
Hereford	0.66	0.62	0.62	0.59	0.28	0.41	0.32
Red Angus	0.92	0.91	0.91	0.89	0.68	0.66	0.68
Shorthorn	0.82	0.80	0.74	0.79	0.61	0.59	0.54
South Devon	0.41	0.45	0.41	0.44	0.06	0.08	0.09
Beefmaster	0.87	0.89	0.86	0.74			
Brahman	0.51	0.48	0.43	0.32	0.08	0.11	0.08
Brangus	0.87	0.81	0.79	0.68			
Santa Gertrudis	0.73	0.66	0.59	0.53	0.20	0.44	0.28
Braunvieh	0.57	0.50	0.40	0.42			
Charolais	0.80	0.75	0.67	0.68	0.48	0.51	0.46
Chiangus	0.82	0.79	0.79	0.74	0.24	0.22	0.33
Gelbvieh	0.82	0.81	0.81	0.79	0.54	0.53	0.54
Limousin	0.93	0.90	0.83	0.84	0.76	0.76	
Maine Anjou	0.80	0.79	0.78	0.78	0.30	0.29	0.33
Salers	0.83	0.82	0.76	0.80	0.25	0.29	0.33
Simmental	0.94	0.94	0.94	0.93	0.73	0.71	0.71
Tarentaise	0.94	0.93	0.91	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)	70.18	479.78	3560.76
Maternal genetic within breed (19 breeds)		435.18	
Maternal permanent environment		723.89	
Residual	53.70	1256.00	4533.89
Carcass Direct	MAR	REA	FAT
Animal within breed (13-14 breeds)	0.280	0.674	0.0105
Residual	0.278	0.737	0.0141

[a]Direct maternal covariance for weaning weight was -61.96 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

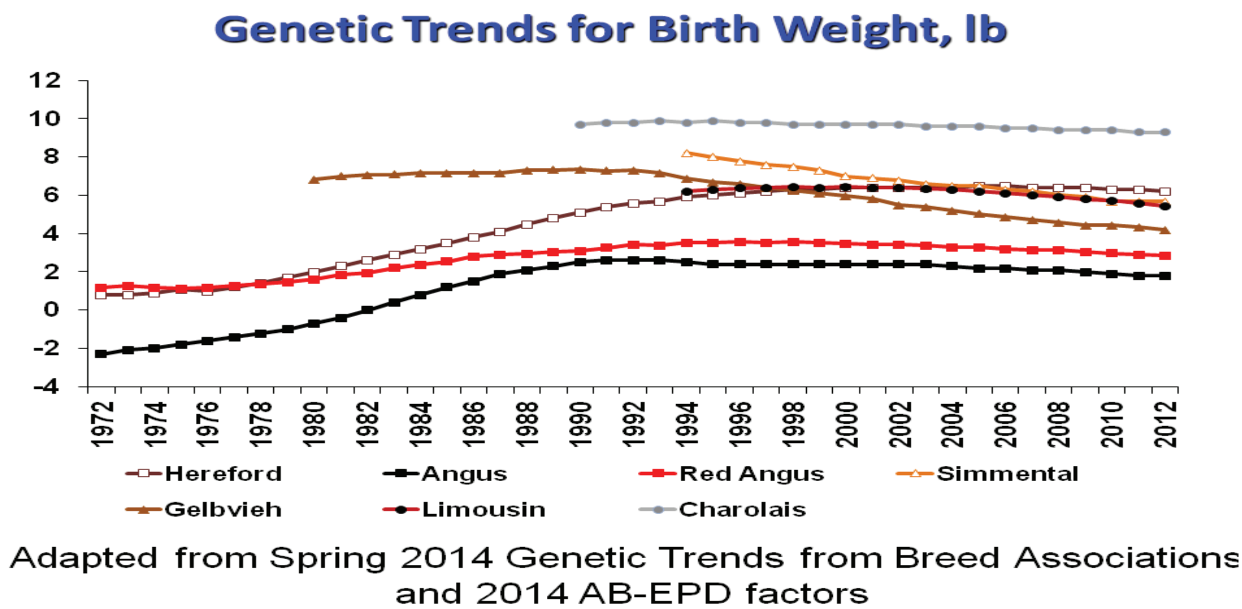
	BWT	WWT	YWT	MILK
Pooled	1.16 ± 0.04	0.84 ± 0.03	1.05 ± 0.04	1.11 ± 0.07
Sire breed				
Angus	1.05 ± 0.09	0.86 ± 0.07	1.23 ± 0.07	1.05 ± 0.15
Hereford	1.18 ± 0.07	0.72 ± 0.05	1.01 ± 0.06	1.05 ± 0.15
Red Angus	1.06 ± 0.14	0.82 ± 0.14	0.60 ± 0.16	1.42 ± 0.27
Shorthorn	0.66 ± 0.21	0.58 ± 0.20	0.52 ± 0.26	1.16 ± 0.71
South Devon	-0.31 ± 0.53	0.67 ± 0.31	0.50 ± 0.32	0.18 ± 1.57
Beefmaster	2.03 ± 0.33	1.00 ± 0.22	0.66 ± 0.34	3.31 ± 0.70
Brahman	1.91 ± 0.21	1.04 ± 0.18	1.35 ± 0.21	-0.05 ± 0.66
Brangus	1.69 ± 0.23	0.94 ± 0.20	1.35 ± 0.28	0.06 ± 0.56
Santa Gertrudis	3.63 ± 0.71	1.04 ± 0.23	1.10 ± 0.29	0.26 ± 0.89
Braunvieh	0.68 ± 0.26	0.59 ± 0.24	0.59 ± 0.38	0.52 ± 0.54
Charolais	1.13 ± 0.12	0.95 ± 0.11	0.85 ± 0.12	1.16 ± 0.24
Chiangus	1.46 ± 0.30	0.17 ± 0.25	0.56 ± 0.29	0.18 ± 0.44
Gelbvieh	1.11 ± 0.14	0.85 ± 0.11	1.13 ± 0.12	0.82 ± 0.25
Limousin	0.99 ± 0.11	1.01 ± 0.09	1.15 ± 0.12	1.81 ± 0.25
Maine Anjou	1.44 ± 0.18	0.92 ± 0.19	0.76 ± 0.25	2.02 ± 0.41
Salers	1.26 ± 0.23	0.80 ± 0.26	0.47 ± 0.25	1.70 ± 0.40
Simmental	1.10 ± 0.14	1.47 ± 0.13	1.33 ± 0.13	0.89 ± 0.31
Tarentaise	0.85 ± 0.59	1.06 ± 0.24	1.48 ± 0.34	1.13 ± 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	0.60 ± 0.04	0.83 ± 0.06	0.94 ± 0.08
Sire breed			
Angus	0.90 ± 0.08	0.75 ± 0.13	1.11 ± 0.15
Hereford	0.66 ± 0.15	0.62 ± 0.13	0.97 ± 0.18
Red Angus	0.76 ± 0.15	1.07 ± 0.20	0.51 ± 0.40
Shorthorn	1.68 ± 0.30	1.66 ± 0.50	1.87 ± 0.48
South Devon	-0.15 ± 0.23	1.64 ± 2.25	5.59 ± 2.65
Brahman	2.57 ± 1.01	1.22 ± 0.36	1.50 ± 0.60
Santa Gertrudis	0.83 ± 0.62	1.12 ± 0.44	0.74 ± 0.46
Charolais	1.29 ± 0.25	1.07 ± 0.27	1.45 ± 0.44
Chiangus	0.57 ± 0.22	0.20 ± 0.43	0.35 ± 0.45
Gelbvieh	1.21 ± 0.20	1.30 ± 0.16	1.70 ± 0.27
Limousin	1.20 ± 0.37	1.22 ± 0.17	
Maine Anjou	0.77 ± 0.68	-0.91 ± 0.48	-1.19 ± 0.73
Salers	0.07 ± 0.07	1.63 ± 0.60	1.29 ± 0.59
Simmental	0.84 ± 0.17	0.69 ± 0.15	0.11 ± 0.31

Figure 1. Relative genetic trends for birth weight (lb) of the seven most highly used beef breeds (1a) and all breeds that submitted 2014 trends (1b) adjusted for birth year 2012 using the 2014 across-breed EPD adjustment factors.

1a.



1b.

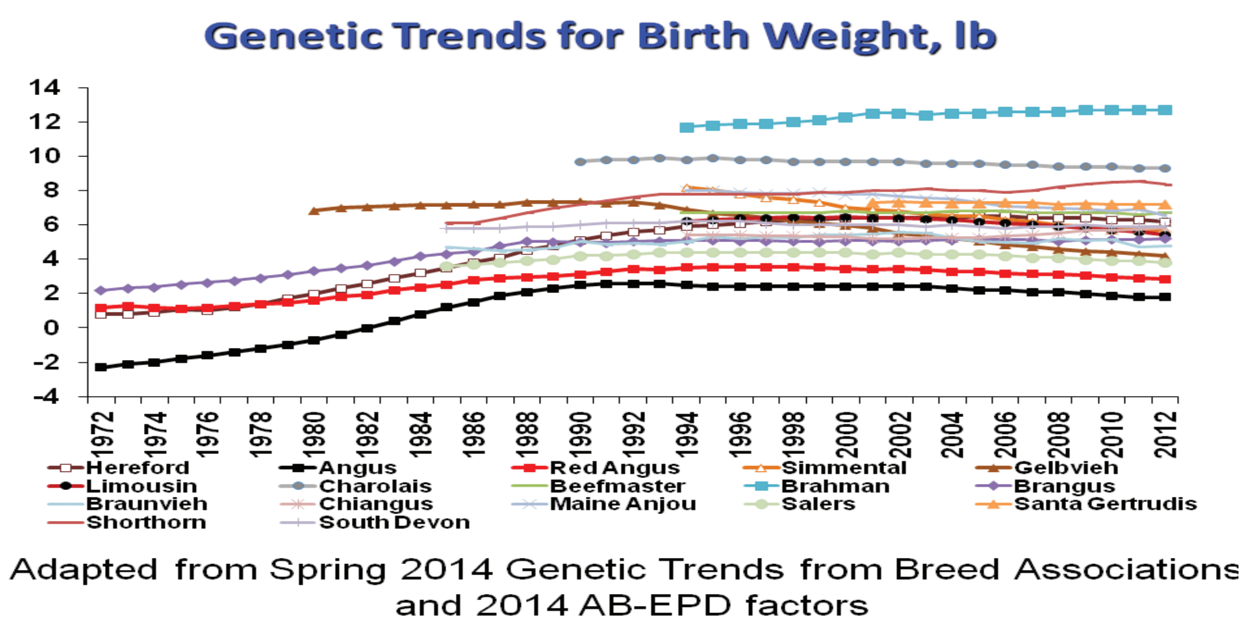
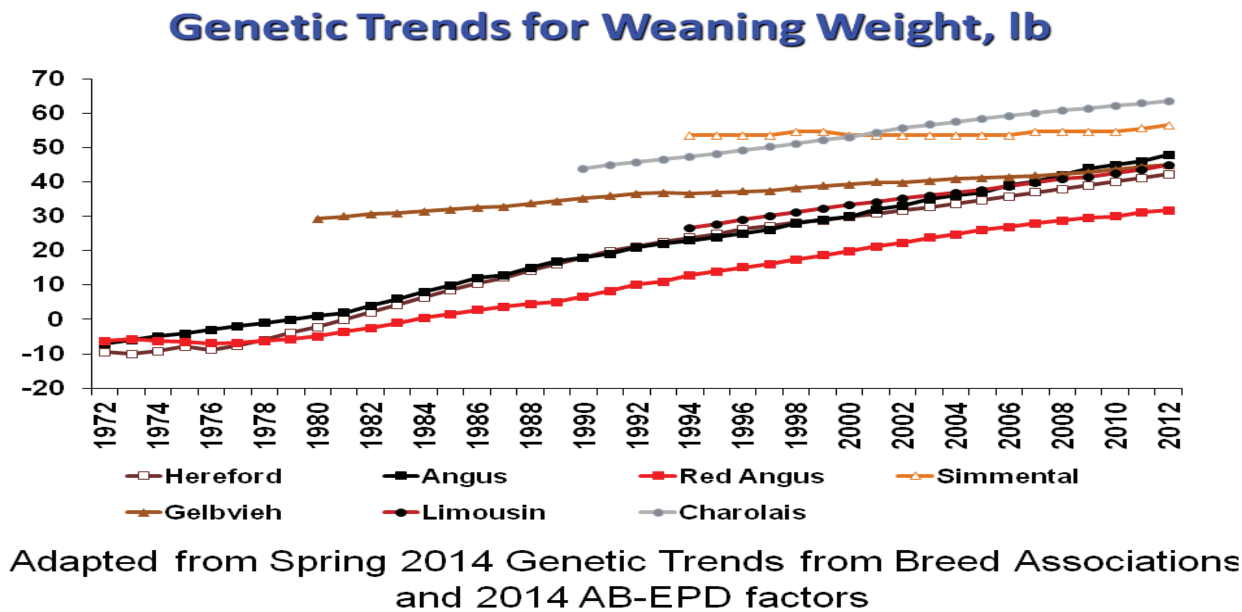


Figure 2. Relative genetic trends for weaning weight (lb) of the seven most highly used beef breeds (2a) and all breeds that submitted 2014 trends (2b) adjusted for birth year 2012 using the 2014 across-breed EPD adjustment factors.

2a.



2b.

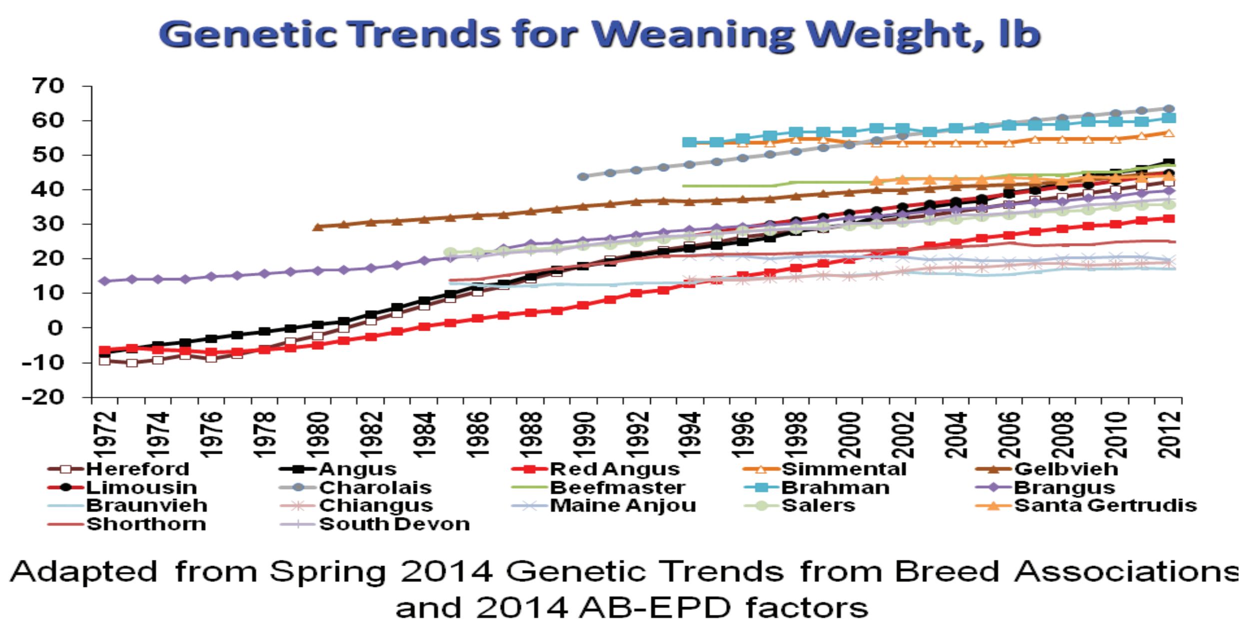
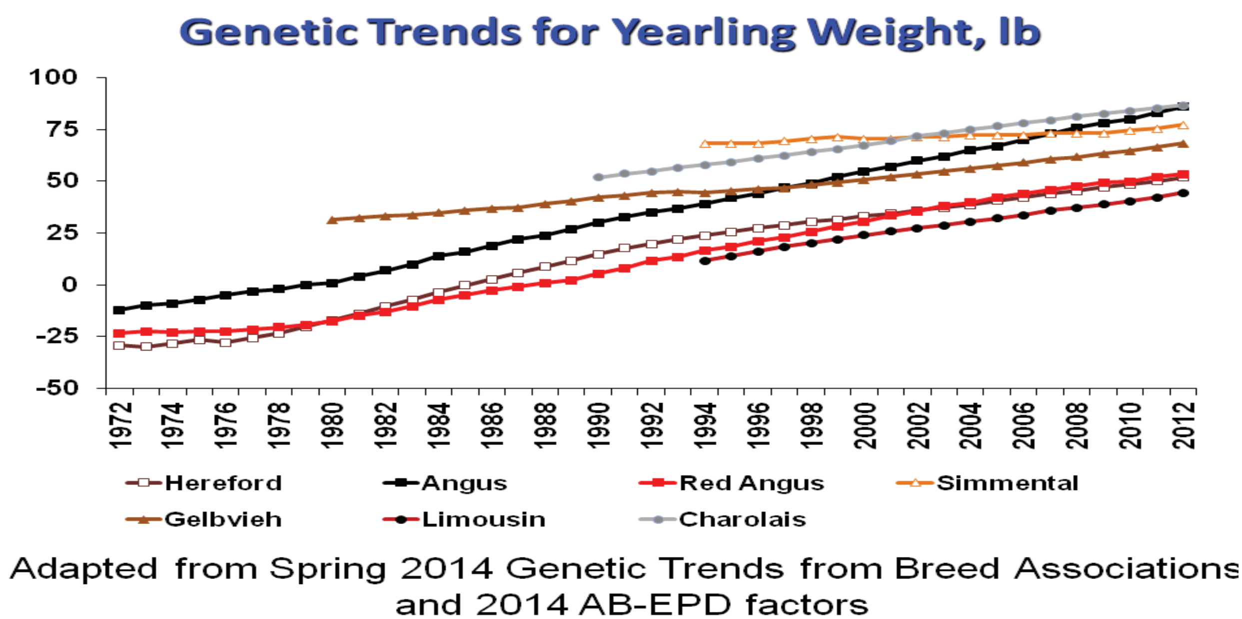


Figure 3. Relative genetic trends for yearling weight (lb) of the seven most highly used beef breeds (3a) and all breeds that submitted 2014 trends (3b) adjusted for birth year 2012 using the 2014 across-breed EPD adjustment factors.

3a.



3b.

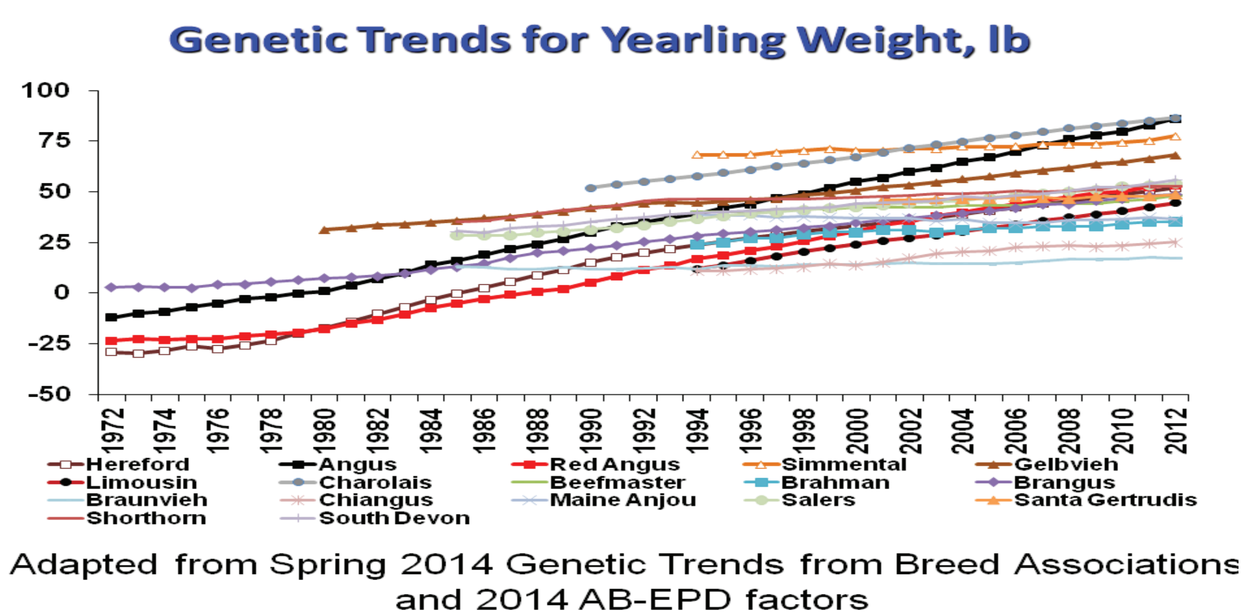
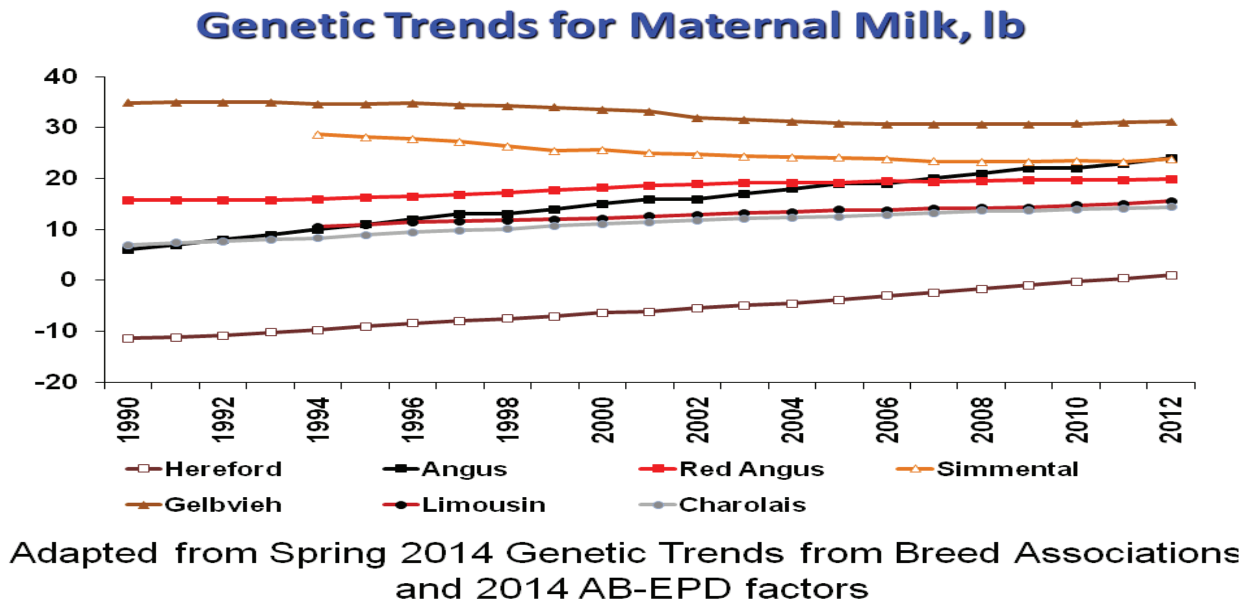
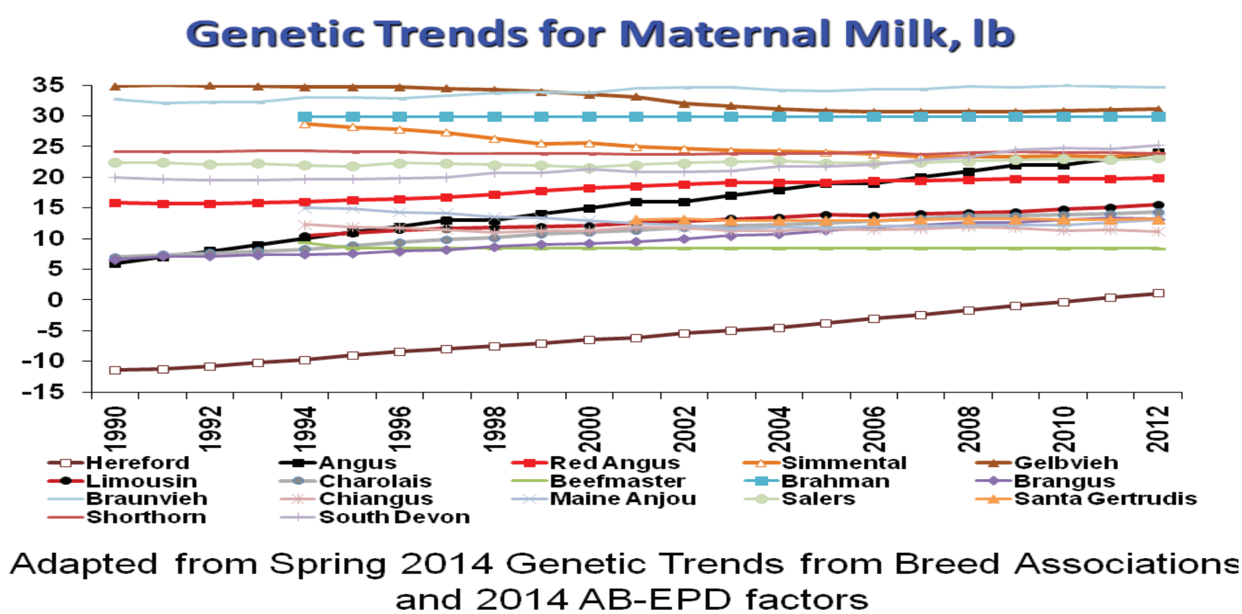


Figure 4. Relative genetic trends for maternal milk (lb) of the seven most highly used beef breeds (4a) and all breeds that submitted 2014 trends (4b) adjusted for birth year 2012 using the 2014 across-breed EPD adjustment factors.

4a.



4b.



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