

MEAN EPDs REPORTED BY DIFFERENT BREEDS

Larry A. Kuehn and R. Mark Thallman

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

Expected progeny differences (EPDs) have been the primary tool for genetic improvement of beef cattle for over 40 years beginning with evaluations of growth traits. Since that time, EPDs have been added for several other production traits such as calving ease, stayability, carcass merit and conformation. Most recently, several breed associations have derived economic indices from their EPDs to increase profit under different management and breeding systems.

It is useful for producers to compare the EPDs of potential breeding animals with their breed average. The current EPDs from the most recent genetic evaluations of 24 breeds are presented in this report. Mean EPDs for growth traits are shown in Table 1 (24 breeds), for other production traits in Table 2 (19 breeds), and for carcass and composition traits in Table 3 (20 breeds). Several breeds also have EPDs and indices that are unique to their breed; these EPDs are presented in Table 4.

Average EPDs should only be used to determine the genetic merit of an animal relative to its breed average. To compare animals of different breeds, across breed adjustment factors should be added to animals' EPDs for their respective breeds (see Across-breed EPD Tables reported by Kuehn and Thallman in these proceedings).

This list is likely incomplete; evaluations for some breeds are not widely reported. We are aware of recent EPD evaluations for the American Akaushi, Blonde d'Aquitaine, North American Piedmontese, American Pinzgauer, and American Waygu breeds but have not found summaries containing current breed averages. If you see a breed missing and would like to report the average EPDs for that breed, please contact Larry (Larry.Kuehn@ars.usda.gov) or Mark (Mark.Thallman@ars.usda.gov).

Table 1. Birth year 2013 average EPDs from 2015 evaluations for growth traits

Breed	Birth Weight (lb)	Weaning Weight (lb)	Yearling Weight (lb)	Maternal Milk (lb)	Total Maternal (lb)
Angus	1.7	50	88	23	
Hereford	3.3	47	77	19	43
Murray Grey	3.7	23	35	4	15
Red Angus	-1.2	56	87	20	
Red Poll	1.6	15	24	6	
Shorthorn	2.2	48	52.7	19.7	41.6
South Devon	2.5	43.2	80.8	24.5	46.2
Beefmaster	0.3	10	14	2	
Braford	1.0	11	17	3	9
Brahman	1.8	16	25.5	5.6	
Brangus	1.1	24.7	46.2	9.5	21.8
Red Brangus	1.5	12.6	19.8	5.0	11.3
Santa Gertrudis	0.2	3.6	5.2	0.3	
Senepol	1.2	12.1	16.5	4.5	9.6
Simbrah	3.9	62.9	85.2	20.7	52.1
Braunvieh	2.9	44.5	69.2	34.3	56.6
Charolais	0.5	26.1	47.5	8.5	21.6
Chianina	2.4	43.3	62.2	16.8	38.3
Gelbvieh	1.0	67.5	97.5	28.3	61.9
Limousin	1.9	64.3	90.6	25.4	
Maine-Anjou	1.2	45.3	59.8	17.1	39.6
Salers	1.5	42	80	19	40
Simmental	2	62.9	91	21.9	53.4
Tarentaise	1.3	17.5	30.8	.7	9.4

Table 2. Birth year 2013 average EPDs from 2015 evaluations for other production traits

Breed	Calving Ease Direct (%)	Calving Ease Maternal (%)	Scrotal Circ (cm)	Docility Score	Mature Weight (lb)	Heifer Pregnancy (%)	Stayability (%)
Angus	4	8	0.82	13	30	10.1	
Hereford	0.9	1.2	0.8		87		
Murray Grey	-0.6	-0.1	0.2		53		
Red Angus	4	5				10	11
Shorthorn	4.0	1.4					
South Devon			0.1				
Beefmaster			0.2				
Brahman				0.0			
Brangus	4.6	3.7	0.48				
Simbrah	2.5	6.4		6.8			
Braunvieh	5.4	0.7	-0.12				
Charolais	3.1	3.5	0.72				
Chianina	5.5	-2.5					
Gelbvieh	10.2	7.2					6.6
Limousin	6.9	5.5	0.14	21.6			19.4
Maine Anjou	7.8	2.4					
Salers	0.4	0.4	0.3	9			23
Simmental	8.6	9.4		9.6			20.6
Tarentaise	-0.1	0.7					

Table 3. Birth year 2013 average EPDs from 2015 evaluations for carcass and composition traits

Breed	Carcass Wt (lb)	Retail Product (%)	Yield Grade	Carcass			Rump fat (in)	WBSF (lb)
				Marbling Score	Ribeye Area (in ²)	Fat Thickness (in)		
Angus	32			0.54	0.51	0.012		
Hereford				0.07	0.30	0.003		
Murray Grey	31	0.4		0.0 ^a	0.10 ^a	0.00 ^a	0.00 ^a	
Red Angus	20		0.01	0.44	0.10	-0.001		
Shorthorn	0.2			0.05	-0.06	-0.030		
South Devon	27.4	0.8		0.4	0.22	0.01		
Beefmaster				0.00 ^a	0.03 ^a	0.01 ^a	0.01 ^a	
Braford	6			0.01	0.06	0.012		
Brahman	1.2	0.00		0.01	0.01	-0.001		0.02
Brangus	23.5			0.00 ^a	0.31 ^a	-0.043 ^a	-0.008 ^a	
Santa Gertrudis	3.3			-0.01	0.03	0.002		
Simbrah	25.6		-0.23	-0.08	0.46	-0.060		-0.03
Braunvieh	20.3			0.57 ^a	0.33 ^a	-0.43 ^a	-0.057 ^a	
Charolais	15.9			0.03	0.28	0.003		
Chianina	10.5	0.33		0.15	0.19	-0.04		
Gelbvieh	28.8		-0.19	0.06	0.45	-0.05		
Limousin	25.9		-0.18	-0.07	0.50			
Maine-Anjou	7.0	0.43		0.04	0.19	-0.051		
Salers	22	0.1		0	0.04	0.00		
Simmental	26.8		-0.32	0.12	0.77	-0.05		-0.32

^aDerived using ultrasound measures and reported on an ultrasound scale (IMF% instead of marbling score)

Table 4. Birth year 2013 average EPDs from 2015 evaluations for other traits unique to individual breeds

Angus	Residual		Cow		Weaned		Grid Value (\$)	Beef Value (\$)	
	Average Daily Gain (lb)	Mature Height (in)	Yearling Height (in)	Energy Value (\$)	Calf Value (\$)	Feedlot Value (\$)			
	0.18	0.3	0.5	-6.98	35.94	34.67	30.24	84.8	
Hereford	Baldy Maternal Index (\$)	Brahman Influence Index (\$)	Certified Hereford Beef Index (\$)	Calving Ease Index (\$)	Udder Score	Teat Score			
	17	15	22	15			1.13	1.13	
Red Angus	Mature Cow Maintenance (Mcal/mo)								
	0								
Gelbvieh	30-Month Pregnancy	DMI (lb/d)	ADG (lb/d)	RFI (lb/d)	\$ Cow (\$)	Efficiency Profit Index (\$)	Feeder Profit Index (\$)		
	0.8	0.008	-0.002	-0.007	69.59	100.82	69.40		
Limousin	Mainstream Terminal Index (\$)								
	47.7								
Simmental	All Purpose Index (\$)	Terminal Index (\$)	Simbrah	All Purpose Index (\$)	Terminal Index (\$)				
	119.4	66.7		69.8	52.4				
Shorthorn	\$ British Maternal								
	\$ Calving Ease	\$ Feedlot	Index						
	21.72	47.81	108.67						
Murray Grey	600-d wt (lb)	Gestational length (d)	Days to calving (d)						
	51	-0.2	-0.8						

ACROSS-BREED EPD TABLES FOR THE YEAR 2015 ADJUSTED TO BREED DIFFERENCES FOR BIRTH YEAR OF 2013

L. A. Kuehn and R. M. Thallman

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 1-8 for birth weight, weaning weight, yearling weight, maternal milk, marbling score, ribeye area, fat thickness, and carcass weight, 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 2015 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 change over time as breeds put selection 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 1-8 contains estimates of the differences between the averages of calves of each breed born in year 2013. 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 2013) 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 2015 update of estimates of sire breed means from data of the Germplasm Evaluation (GPE) project at USMARC adjusted to a year 2013 basis using EPD from the most recent national cattle evaluations. The 2013 basis year is chosen because yearling records for weight and carcass traits should have been accounted for in EPDs for progeny born in 2013 in the Spring 2015 EPD national genetic evaluations. Factors to adjust Spring 2015 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 5-8 summarize the factors for marbling score (MAR), ribeye area (REA), fat thickness (FAT), and carcass weight (CWT).

The across-breed table adjustments apply **only** to EPD for most recent (spring, 2015)

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 2014 (Kuehn and Thallman, 2014):

This year we are reporting breed differences and adjustment factors for carcass weight for the first time (Table 8). Like other carcass traits in this report, these carcass weight differences are derived by accounting for age (rather than weight or fat). The differences and factors are reported for all breeds in the program that report a carcass weight EPD.

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 carcass traits) 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 1-8) 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 (2012-2014). 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 F₁ 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, FAT, and CWT), 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 (vs. ultrasound) 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 1-8. 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 1/2 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, FAT, and CWT, 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,

EPD(i)_{YY} is the average within-breed 2015 EPD for breed i for animals born in the base year (YY, which is two years before the update; e.g., YY = 2013 for the 2015 update),

EPD(i)_{USMARC} is the weighted (by total relationship of descendants with records at USMARC) average of 2015 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 2015: 1.17, 0.80, 0.98, and 1.11 BWT, WWT, YWT, and MILK, respectively; 1.00 was applied to MAR, REA, FAT, and CWT 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 1.71 lb, 14.59 lb, 23.73 lb, -0.03 marbling score units (i.e. $4.00 = S1^{00}$, $5.00 = S_m^{00}$), 0.28 in², 0.033, and 30.39 lb in for BWT, WWT, YWT, MAR, REA, FAT, and CWT respectively. These estimates are interpreted as the amount by which the performance of an F₁ is expected to exceed that of its parental breeds. The estimate of maternal heterosis for WWT was 8.32 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 2013 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 2013 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 2013) 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 2010 through 2014 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 1-8. 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 1-8 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 Gelbvieh bull is +98.0 (which is above the birth year 2013 average of 97.5 for Gelbvieh) and for a Simmental bull is +89.0 (which is below the birth year 2013 average of 91.0 for Simmental). The across-breed adjustment factors in the last column of Table 3 are -30.4 for Gelbvieh and -9.5 for Simmental. Then the adjusted EPD for the Gelbvieh bull is $98.0 + (-30.4) = 67.6$ and for the Simmental bull is $89.0 + (-9.5) = 79.5$. The expected yearling weight difference when both are mated to another breed of cow, e.g., Hereford, would be $67.6 - 79.5 = -11.9$ 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 relative to Angus for BWT (Table 1, column 5) ranged from 0.5 lb for Red Angus to 7.4 lb for Charolais and 11.0 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 1.0 lb for all breeds relative to last year's update (Kuehn and Thallman, 2014).

Weaning Weight

All of the 17 breed differences (Table 2, column 5) were within 5 lb of the values reported by Kuehn and Thallman. (2014) except for Shorthorn. Shorthorn did have a change of base in their last evaluation, which may be part of the cause; the mean EPD of sires sampled at USMARC changed relative to this new base. Otherwise, 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 (2014) in general. Again, Shorthorn changed more relative to other breeds also likely because of a base change in their yearling weight EPD. 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 7 lb difference from those reported in 2014. 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. Females from newly sampled South Devon or Tarentaise sires have just begun to have progeny in this update; however, difference from Angus changed very little in these breeds.. We would expect their solutions to change the most in future reports.

Marbling, Ribeye Area, Fat Thickness and Carcass Weight

Most changes to breed of sire differences were minor for each of these carcass traits. The Salers breed average for marbling decreased (Table 5, column 1) 0.20 marbling score units while average EPD of USMARC sampled bulls (Table 5, column 2) had little change relative to last year's update. Hence, their marbling score difference decreased by approximately 0.20 compared to Kuehn and Thallman (2014). Carcass weight differences and factors are reported for the first time in this update.

Accuracies and Variance Components

Table 9 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 10 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 0.56, 0.17, 0.44, and 0.16, respectively. Heritability estimates for MAR, REA, FAT, and CWT were 0.46, 0.49, 0.41, and 0.51 respectively.

Regression Coefficients

Table 11 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 1.17 for BWT, 0.80 for WWT, and 0.98 for YWT were used to adjust breed of sire solutions to the base year of 2013. 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 11. 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, FAT, and CWT 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 higher, though they have decreased from the previous year. The MAR regressions were the most variable, possibly because the primary source of marbling variation in many of the breeds is ultrasound-estimated intramuscular fat which generally exhibits a lower level of variation. While REA, FAT, and CWT 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 three 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/content/uploads/2013/07/BIF-Proceedings5.pdf>). 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 2013 base and factors to adjust within breed EPD to an Angus equivalent – BIRTH WEIGHT (lb)

Breed	Number		Ave. Base EPD		Breed Soln at USMARC (vs Ang) (3)	BY 2013 Sire Breed Average (4)	BY 2013 Sire Breed Difference ^a (5)	Factor to adjust EPD To Angus (6)
	AI Sires	Direct Progeny	Breed 2013 (1)	USMARC Bulls (2)				
Angus	162	2095	1.7	1.9	0.0	86.6	0.0	0.0
Hereford	160	2449	3.3	2.3	3.6	90.9	4.3	2.7
Red Angus	57	749	-1.2	-1.9	-0.3	87.2	0.5	3.4
Shorthorn	60	557	2.2	2.6	6.8	92.3	5.6	5.1
South Devon	28	213	2.5	2.1	4.5	91.0	4.4	3.6
Beefmaster	56	509	0.3	0.9	5.5	90.9	4.3	5.7
Brahman	57	706	1.8	0.6	11.3	97.7	11.0	10.9
Brangus	57	518	1.1	1.0	3.5	89.9	3.3	3.9
Santa Gertrudis	24	311	0.2	0.6	6.6	92.1	5.4	6.9
Braunvieh	33	480	2.9	4.1	5.6	90.4	3.7	2.5
Charolais	111	1205	0.5	0.2	8.1	94.0	7.4	8.6
Chiangus	26	326	2.4	2.2	4.5	90.9	4.2	3.5
Gelbvieh	82	1091	1.0	2.8	4.2	88.6	2.0	2.7
Limousin	76	1171	1.9	1.5	3.1	89.9	3.2	3.0
Maine Anjou	51	547	1.2	2.2	6.2	91.2	4.5	5.0
Salers	52	497	1.5	2.4	3.3	88.7	2.0	2.2
Simmental	90	1216	2.0	3.2	5.8	90.6	3.9	3.6
Tarentaise	17	265	1.3	2.0	3.8	89.3	2.7	3.1

Calculations:

$$(4) = (3) / b + [(1) - (2)] + (\text{Recent Raw Angus Mean: } 86.8 \text{ lb}) \text{ with } b = 1.17$$

$$(5) = (4) - (4, \text{Angus})$$

$$(6) = (5) - (5, \text{Angus}) - [(1) - (1, \text{Angus})]$$

^aThe 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 2013 base and factors to adjust within breed EPD to an Angus equivalent – WEANING WEIGHT (lb)

Breed	Number		Ave. Base EPD		Breed Soln	BY 2013	BY 2013	Factor to adjust EPD To Angus (6)
	AI Sires	Direct Progeny	Breed 2013 (1)	USMARC Bulls (2)	at USMARC (vs Ang) (3)	Sire Breed Average (4)	Sire Breed Difference ^a (5)	
Angus	162	1935	50.0	29.0	0.0	570.2	0.0	0.0
Hereford	158	2263	47.0	28.4	-4.0	562.8	-7.4	-4.4
Red Angus	57	717	56.0	50.5	-3.4	550.5	-19.7	-25.7
Shorthorn	60	526	48.0	53.8	-4.7	537.5	-32.7	-30.7
South Devon	28	194	43.2	27.2	-7.9	555.4	-14.8	-8.0
Beefmaster	56	481	10.0	11.9	15.2	566.3	-3.9	36.1
Brahman	56	613	16.0	6.4	19.9	583.7	13.5	47.5
Brangus	57	494	24.7	22.3	5.7	558.7	-11.4	13.9
Santa Gertrudis	24	294	3.6	6.5	15.1	565.2	-5.0	41.4
Braunvieh	33	445	44.5	46.3	-3.9	542.5	-27.6	-22.1
Charolais	110	1096	26.1	14.6	20.2	585.9	15.7	39.6
Chiangus	26	291	43.3	46.3	-7.8	536.6	-33.6	-26.9
Gelbvieh	82	1023	67.5	60.9	8.3	566.2	-4.0	-21.5
Limousin	76	1076	64.3	46.2	0.2	567.5	-2.7	-17.0
Maine Anjou	51	509	45.3	46.1	-6.0	541.0	-29.2	-24.5
Salers	52	472	42.0	34.5	1.1	558.1	-12.1	-4.1
Simmental	88	1112	62.9	56.3	18.0	578.3	8.1	-4.8
Tarentaise	17	257	17.5	-1.9	-2.2	565.9	-4.2	28.3

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 549.2 lb) with b = 0.80

(5) = (4) – (4, Angus)

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

^aThe 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 2013 base and factors to adjust within breed EPD to an Angus equivalent – YEARLING WEIGHT (lb)

Breed	AI	Number		Ave. Base EPD		Breed Soln	BY 2013	BY 2013	Factor to adjust EPD To Angus
		Direct	Progeny	Breed 2013	USMARC Bulls	at USMARC (vs Ang)	Sire Breed Average	Sire Breed Difference ^a	
	Sires			(1)	(2)	(3)	(4)	(5)	(6)
Angus	153	1699		88.0	50.3	0.0	1041.9	0.0	0.0
Hereford	147	2074		77.0	47.3	-29.1	1004.2	-37.6	-26.6
Red Angus	49	643		87.0	73.1	-8.0	1009.9	-31.9	-30.9
Shorthorn	55	475		52.7	60.4	-2.1	994.3	-47.6	-12.3
South Devon	25	176		80.8	55.0	-20.8	1008.7	-33.1	-25.9
Beefmaster	53	386		14.0	18.1	0.1	1000.2	-41.7	32.3
Brahman	56	541		25.5	11.0	-29.5	988.5	-53.3	9.2
Brangus	53	399		46.2	40.8	-4.4	1005.1	-36.7	5.1
Santa Gertrudis	21	261		5.2	10.1	1.9	1001.2	-40.6	42.2
Braunvieh	30	420		69.2	72.0	-27.0	973.8	-68.1	-49.3
Charolais	105	993		47.5	28.4	18.5	1042.2	0.3	40.8
Chiangus	24	254		62.2	62.9	-25.8	977.2	-64.6	-38.8
Gelbvieh	79	970		97.5	79.4	-1.3	1020.9	-20.9	-30.4
Limousin	66	992		90.6	61.5	-30.2	1002.5	-39.4	-42.0
Maine Anjou	48	472		59.8	62.1	-22.8	978.6	-63.2	-35.0
Salers	50	438		80.0	65.8	-10.6	1007.6	-34.3	-26.3
Simmental	84	961		91.0	81.7	21.4	1035.3	-6.5	-9.5
Tarentaise	17	234		30.8	1.1	-38.8	994.3	-47.6	9.6

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 1004.2 lb) with b = 0.98

(5) = (4) – (4, Angus)

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

^aThe 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 2013 base and factors to adjust within breed EPD to an Angus equivalent – MILK (lb)

Breed	AI Sires	Number		Ave. Base EPD		Breed Soln at USMARC (vs Ang) (3)	BY 2013 Sire Breed Average (4)	BY 2013 Sire Breed Difference ^a (5)	Factor to adjust EPD To Angus (6)
		Direct Gpr	Direct Progeny	Breed 2013 (1)	USMARC Bulls (2)				
Angus	133	2999	709	23.0	14.0	0.0	558.2	0.0	0.0
Hereford	134	3677	895	19.0	10.6	-23.6	536.4	-21.8	-17.8
Red Angus	46	906	257	20.0	16.6	5.5	557.6	-0.6	2.4
Shorthorn	47	457	172	19.7	20.8	12.6	559.5	1.3	4.6
South Devon	24	368	90	24.5	20.1	9.4	562.1	3.9	2.4
Beefmaster	41	374	120	2.0	0.0	-2.4	549.1	-9.1	11.9
Brahman	55	836	249	5.6	7.1	18.5	564.4	6.2	23.6
Brangus	41	358	111	9.5	5.6	-4.2	549.3	-8.9	4.6
Santa Gertrudis	21	207	102	0.3	-1.8	-1.8	549.7	-8.5	14.2
Braunvieh	28	674	174	34.3	33.7	21.4	569.1	10.9	-0.4
Charolais	92	1628	413	8.5	5.9	-0.9	551.0	-7.2	7.3
Chiangus	24	203	99	16.8	13.5	-0.4	552.2	-6.0	0.2
Gelbvieh	73	1548	379	28.3	31.8	21.6	565.1	6.9	1.6
Limousin	63	1770	423	25.4	22.6	-0.3	551.8	-6.4	-8.8
Maine Anjou	41	676	184	17.1	16.1	-1.6	548.7	-9.5	-3.6
Salers	46	554	184	19.0	19.7	11.8	559.1	0.9	4.9
Simmental	71	1745	427	21.9	25.7	16.9	560.7	2.5	3.6
Tarentaise	14	363	100	0.7	4.0	14.8	559.3	1.1	23.4

Calculations:

$$(4) = (3) / b + [(1) - (2)] + (\text{Raw Angus Mean: } 549.2 \text{ lb}) \text{ with } b = 1.11$$

$$(5) = (4) - (4, \text{Angus})$$

$$(6) = (5) - (5, \text{Angus}) - [(1) - (1, \text{Angus})]$$

^aThe 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 2013 base and factors to adjust within breed EPD to an Angus equivalent – MARBLING (marbling score units^a)

Breed	AI Sires	Number Direct Progeny	Ave. Base EPD		Breed Soln	BY 2013	BY 2013	Factor to adjust EPD To Angus (6)
			Breed 2013 (1)	USMARC Bulls (2)	at USMARC (vs Ang) (3)	Sire Breed Average (4)	Sire Breed Difference ^b (5)	
Angus	130	765	0.54	0.20	0.00	6.14	0.00	0.00
Hereford	144	972	0.07	0.00	-0.52	5.36	-0.79	-0.32
Red Angus	47	242	0.44	0.47	-0.06	5.72	-0.42	-0.32
Shorthorn	54	248	0.05	0.09	-0.35	5.41	-0.73	-0.24
South Devon	22	68	0.40	-0.07	-0.36	5.92	-0.23	-0.09
Brahman	55	227	0.01	-0.01	-1.04	4.79	-1.36	-0.83
Santa Gertrudis	21	126	-0.01	-0.02	-0.84	4.97	-1.17	-0.62
Charolais	52	274	0.03	-0.04	-0.63	5.25	-0.90	-0.39
Chiangus	24	123	0.15	0.15	-0.45	5.36	-0.79	-0.40
Gelbvieh	77	426	0.06	-0.24	-0.77	5.34	-0.81	-0.33
Limousin	62	404	-0.07	-0.15	-0.95	4.94	-1.21	-0.60
Maine Anjou	48	237	0.04	0.03	-0.78	5.04	-1.10	-0.60
Salers	46	213	0.00	-0.36	-0.70	5.46	-0.68	-0.14
Simmental	80	454	0.12	-0.02	-0.60	5.35	-0.80	-0.38

Calculations:

$$(4) = (3) / b + [(1) - (2)] + (\text{Raw Angus Mean: } 5.81) \text{ with } b = 1.00$$

$$(5) = (4) - (4, \text{Angus})$$

$$(6) = (5) - (5, \text{Angus}) - [(1) - (1, \text{Angus})]$$

$$^a 4.00 = S1^{00}, 5.00 = S2^{00}$$

^bThe 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 2013 base and factors to adjust within breed EPD to an Angus equivalent – RIBEYE AREA (in²)

Breed	Number		Ave. Base EPD		Breed Soln	BY 2013	BY 2013	Factor to adjust EPD To Angus (6)
	AI Sires	Direct Progeny	Breed 2013 (1)	USMARC Bulls (2)	at USMARC (vs Ang) (3)	Sire Breed Average (4)	Sire Breed Difference ^a (5)	
Angus	130	766	0.51	0.09	0.00	13.24	0.00	0.00
Hereford	144	972	0.30	-0.04	-0.22	12.93	-0.31	-0.10
Red Angus	47	242	0.10	-0.12	-0.18	12.86	-0.38	0.03
Shorthorn	54	248	-0.06	-0.07	0.16	12.98	-0.26	0.31
South Devon	22	68	0.22	0.21	0.33	13.16	-0.08	0.21
Brahman	55	232	0.01	0.05	-0.14	12.63	-0.61	-0.11
Santa Gertrudis	21	127	-0.01	0.02	-0.13	12.66	-0.58	-0.06
Charolais	52	275	0.28	0.12	1.01	13.99	0.75	0.98
Chiangus	24	124	0.19	0.18	0.43	13.26	0.02	0.34
Gelbvieh	77	428	0.45	0.36	0.92	13.83	0.59	0.65
Limousin	62	405	0.50	0.37	1.26	14.21	0.97	0.98
Maine Anjou	48	237	0.19	0.21	0.90	13.70	0.46	0.78
Salers	46	214	0.04	0.03	0.79	13.62	0.38	0.85
Simmental	80	455	0.77	0.55	0.89	13.93	0.69	0.43

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 12.82 in²) with b = 1.00

(5) = (4) – (4, Angus)

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

^aThe 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 2013 base and factors to adjust within breed EPD to an Angus equivalent – FAT THICKNESS (in)

Breed	Number		Ave. Base EPD		Breed Soln	BY 2013	BY 2013	Factor to adjust EPD To Angus (6)
	AI Sires	Direct Progeny	Breed 2013 (1)	USMARC Bulls (2)	at USMARC (vs Ang) (3)	Sire Breed Average (4)	Sire Breed Difference ^a (5)	
Angus	130	766	0.012	0.002	0.000	0.668	0.000	0.000
Hereford	144	971	0.003	-0.003	-0.058	0.606	-0.062	-0.053
Red Angus	47	241	-0.001	-0.009	-0.034	0.632	-0.036	-0.023
Shorthorn	54	248	-0.030	-0.031	-0.140	0.519	-0.149	-0.107
South Devon	22	68	0.010	0.008	-0.123	0.537	-0.131	-0.129
Brahman	55	232	-0.001	-0.002	-0.150	0.509	-0.159	-0.146
Santa Gertrudis	21	127	0.002	0.002	-0.097	0.561	-0.107	-0.097
Charolais	52	274	0.003	0.005	-0.205	0.452	-0.216	-0.207
Chiangus	24	123	-0.040	-0.025	-0.141	0.502	-0.166	-0.114
Gelbvieh	77	426	-0.050	-0.083	-0.202	0.490	-0.179	-0.117
Maine Anjou	48	237	-0.050	-0.029	-0.223	0.414	-0.254	-0.192
Salers	46	214	0.000	-0.007	-0.212	0.453	-0.215	-0.203
Simmental	80	455	-0.050	-0.052	-0.192	0.469	-0.199	-0.137

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 0. 658 in) with b = 1.00

(5) = (4) – (4, Angus)

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

^aThe breed difference estimates represent half the differences that would be expected between purebreds of the two breeds.

Table 8. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2013 base and factors to adjust within breed EPD to an Angus equivalent – CARCASS WEIGHT (lb)

Breed	AI Sires	Number Direct Progeny	Ave. Base EPD		Breed Soln at USMARC (vs Ang) (3)	BY 2013 Sire Breed Average (4)	BY 2013 Sire Breed Difference ^a (5)	Factor to adjust EPD To Angus (6)
			Breed 2013 (1)	USMARC Bulls (2)				
Angus	130	766	32	12.4	0.0	904.9	0.0	0.0
Red Angus	47	242	20	10.6	-8.0	886.6	-18.2	-6.2
Shorthorn	54	248	0.22	8.6	-15.5	861.4	-43.4	-11.6
South Devon	22	68	27.4	15.2	-19.6	877.9	-26.9	-22.3
Brahman	55	233	1.2	-0.5	-41.4	845.5	-59.3	-28.5
Brangus	50	242	23.5	18.6	-6.3	883.9	-21.0	-12.5
Santa Gertrudis	21	127	3.3	6.0	-11.8	870.8	-34.1	-5.4
Braunvieh	30	196	20.3	14.4	-42.9	848.3	-56.6	-44.9
Charolais	52	275	15.9	11.1	4.1	894.2	-10.7	5.4
Chiangus	24	124	10.5	9.5	-23.8	862.4	-42.4	-20.9
Gelbvieh	77	428	28.8	19.0	-16.0	879.1	-25.8	-22.6
Limousin	62	405	25.9	5.8	-20.0	885.4	-19.5	-13.4
Maine Anjou	48	237	7	10.4	-25.6	856.3	-48.6	-23.6
Salers	46	215	22	14.9	-27.2	865.2	-39.7	-29.7
Simmental	80	455	26.8	20.6	12.0	903.4	-1.4	3.8

Calculations:

(4) = (3) / b + [(1) – (2)] + (Raw Angus Mean: 885.3 lb) with b = 1.00

(5) = (4) – (4, Angus)

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

Table 9. 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), fat thickness (FAT), and carcass weight (CWT) for bulls used at USMARC

Breed	BWT	WWT	YWT	MILK	MAR	REA	FAT	CWT
Angus	0.81	0.78	0.73	0.74	0.54	0.53	0.51	0.51
Hereford	0.67	0.63	0.63	0.60	0.29	0.41	0.33	
Red Angus	0.92	0.92	0.91	0.89	0.68	0.66	0.68	0.60
Shorthorn	0.82	0.81	0.80	0.80	0.45	0.43	0.45	0.57
South Devon	0.44	0.47	0.42	0.49	0.06	0.09	0.10	0.33
Beefmaster	0.88	0.90	0.86	0.75				
Brahman	0.52	0.49	0.43	0.33	0.09	0.11	0.09	0.26
Brangus	0.88	0.82	0.71	0.71				0.68
Santa Gertrudis	0.73	0.67	0.58	0.54	0.40	0.49	0.50	0.45
Braunvieh	0.62	0.55	0.31	0.49				0.26
Charolais	0.81	0.75	0.68	0.70	0.49	0.52	0.46	0.47
Chiangus	0.81	0.78	0.78	0.74	0.24	0.21	0.33	0.56
Gelbvieh	0.85	0.83	0.83	0.81	0.62	0.57	0.59	0.55
Limousin	0.93	0.93	0.93	0.92	0.66	0.65		0.60
Maine Anjou	0.80	0.79	0.79	0.79	0.31	0.30	0.34	0.56
Salers	0.83	0.82	0.76	0.80	0.27	0.30	0.35	0.61
Simmental	0.94	0.94	0.94	0.93	0.73	0.71	0.71	0.60
Tarentaise	0.93	0.92	0.92	0.88				

^aWeighted 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 10. Estimates of variance components (lb²) for birth weight (BWT), weaning weight (WWT), yearling weight (YWT), and maternal weaning weight (MWWT) and for marbling (MAR; marbling score units²), ribeye area (REA; in⁴), fat thickness (FAT; in²), and carcass weight (CWT; lb) from mixed model analyses

Analysis	BWT	WWT ^a	YWT	
Animal within breed (18 breeds)	69.40	483.34	3612.43	
Maternal genetic within breed (18 breeds)		444.29		
Maternal permanent environment		719.55		
Residual	55.63	1263.93	4551.99	

Carcass Direct	MAR	REA	FAT	CWT
Animal within breed (13-16 breeds)	0.269	0.644	0.0102	2335.22
Residual	0.281	0.768	0.0145	2252.06

^aDirect maternal covariance for weaning weight was -54.15 lb²

Table 11. Pooled and within-breed regression coefficients (lb/lb) for weights at birth (BWT), 205 days (WWT), and 365 days (YWT) of F₁ progeny and for calf weights (205 d) of F₁ dams (MILK) on sire expected progeny difference and by sire breed

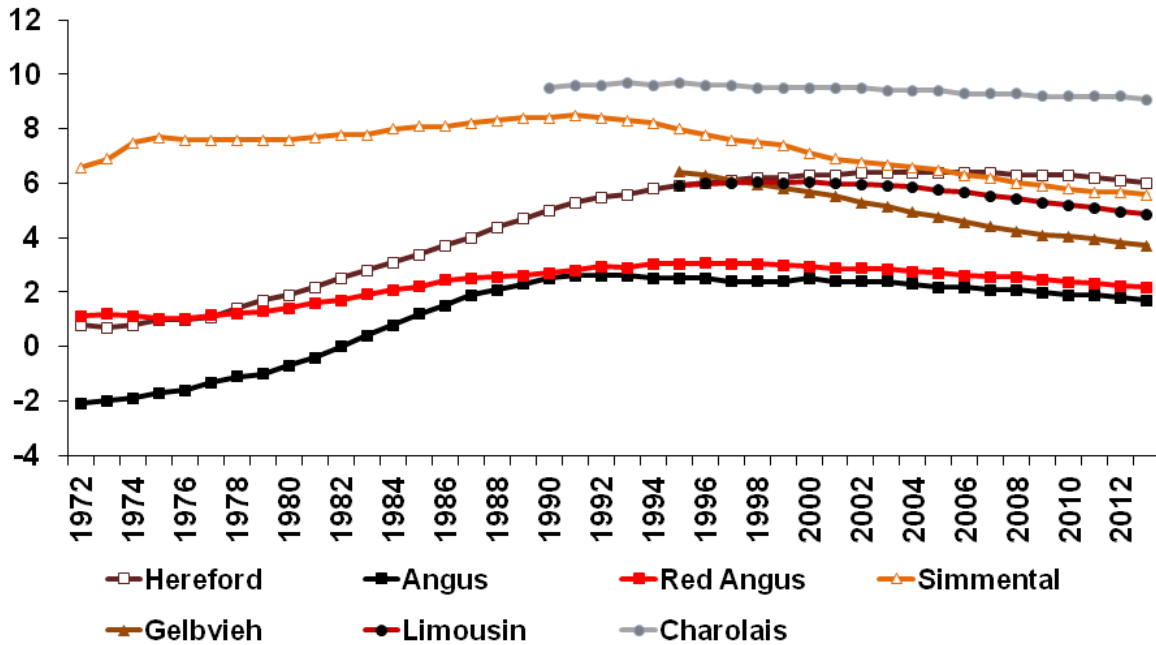
	BWT	WWT	YWT	MILK
Pooled	1.17 ± 0.04	0.80 ± 0.03	0.98 ± 0.04	1.11 ± 0.07
Sire breed				
Angus	1.06 ± 0.09	0.83 ± 0.06	1.18 ± 0.07	1.08 ± 0.15
Hereford	1.16 ± 0.07	0.71 ± 0.05	1.00 ± 0.06	1.03 ± 0.15
Red Angus	1.01 ± 0.14	0.74 ± 0.13	0.61 ± 0.15	1.34 ± 0.26
Shorthorn	0.75 ± 0.21	0.52 ± 0.14	0.55 ± 0.17	1.00 ± 0.43
South Devon	-0.24 ± 0.53	0.80 ± 0.29	0.50 ± 0.32	1.08 ± 1.06
Beefmaster	2.08 ± 0.33	0.98 ± 0.21	0.76 ± 0.31	3.41 ± 0.67
Brahman	1.93 ± 0.21	1.08 ± 0.18	1.36 ± 0.22	0.09 ± 0.62
Brangus	1.49 ± 0.23	0.74 ± 0.20	0.81 ± 0.18	0.28 ± 0.58
Santa Gertrudis	3.75 ± 0.71	1.31 ± 0.25	1.15 ± 0.29	0.78 ± 1.00
Braunvieh	0.88 ± 0.26	0.63 ± 0.28	0.31 ± 0.27	1.54 ± 0.65
Charolais	1.14 ± 0.12	0.96 ± 0.11	0.86 ± 0.12	1.06 ± 0.22
Chiangus	1.44 ± 0.30	0.13 ± 0.24	0.35 ± 0.28	0.19 ± 0.41
Gelbvieh	1.05 ± 0.14	0.81 ± 0.11	1.15 ± 0.12	0.84 ± 0.25
Limousin	1.11 ± 0.11	0.80 ± 0.07	0.86 ± 0.09	1.42 ± 0.21
Maine Anjou	1.40 ± 0.18	0.97 ± 0.19	0.83 ± 0.24	2.02 ± 0.39
Salers	1.26 ± 0.23	0.82 ± 0.25	0.60 ± 0.24	1.70 ± 0.38
Simmental	1.16 ± 0.14	1.44 ± 0.12	1.33 ± 0.12	0.95 ± 0.30
Tarentaise	0.70 ± 0.59	1.07 ± 0.24	1.55 ± 0.37	1.49 ± 0.81

Table 12. Pooled and within-breed regression coefficients marbling (MAR; score/score), ribeye area (REA; in²/in²), fat thickness (FAT; in/in), and carcass weight (CWT; lb) of F₁ progeny on sire expected progeny difference and by sire breed

	MAR	REA	FAT	CWT
Pooled	0.55 ± 0.04	0.80 ± 0.06	0.96 ± 0.08	0.90 ± 0.06
Sire breed				
Angus	0.84 ± 0.08	0.78 ± 0.13	1.05 ± 0.14	0.99 ± 0.11
Hereford	0.68 ± 0.14	0.64 ± 0.13	0.99 ± 0.17	
Red Angus	0.75 ± 0.15	1.17 ± 0.20	0.67 ± 0.36	1.20 ± 0.24
Shorthorn	1.52 ± 0.29	0.58 ± 0.35	1.44 ± 0.46	0.55 ± 0.28
South Devon	-0.08 ± 0.18	2.08 ± 2.36	4.24 ± 2.54	-0.66 ± 0.88
Brahman	1.97 ± 0.94	1.13 ± 0.36	1.25 ± 0.57	0.53 ± 0.27
Brangus				0.78 ± 0.24
Santa Gertrudis	1.07 ± 0.62	0.85 ± 0.48	1.31 ± 0.88	1.37 ± 0.49
Braunvieh				0.18 ± 0.23
Charolais	1.11 ± 0.20	0.80 ± 0.18	1.33 ± 0.38	0.54 ± 0.30
Chiangus	0.55 ± 0.20	0.22 ± 0.44	0.53 ± 0.39	0.75 ± 0.46
Gelbvieh	1.23 ± 0.19	1.33 ± 0.16	1.98 ± 0.30	1.46 ± 0.20
Limousin	0.86 ± 0.27	0.74 ± 0.14		0.75 ± 0.15
Maine Anjou	-0.12 ± 0.65	-0.79 ± 0.47	-0.84 ± 0.53	1.41 ± 0.33
Salers	0.05 ± 0.07	1.14 ± 0.55	0.90 ± 0.58	0.41 ± 0.47
Simmental	0.83 ± 0.16	0.63 ± 0.15	0.07 ± 0.29	1.59 ± 0.23

Figure 1. Relative genetic trends for birth weight (lb) of the seven most highly used beef breeds (1a) and all breeds that submitted 2015 trends (1b) adjusted for birth year 2013 using the 2015 across-breed EPD adjustment factors.

1a.



1b.

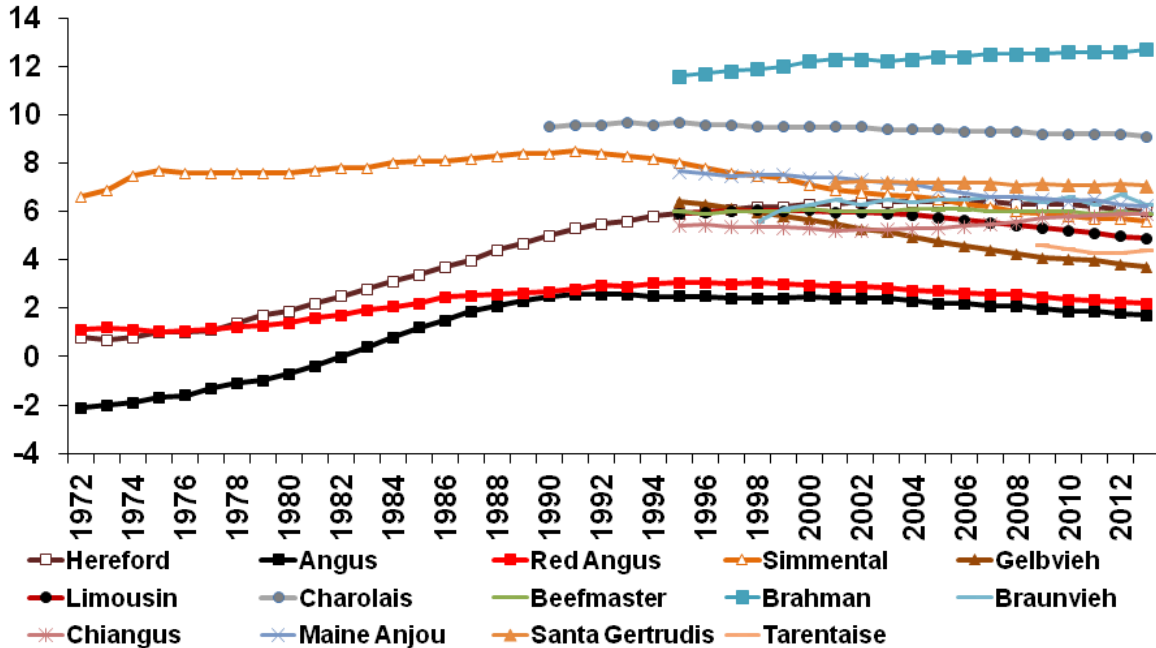
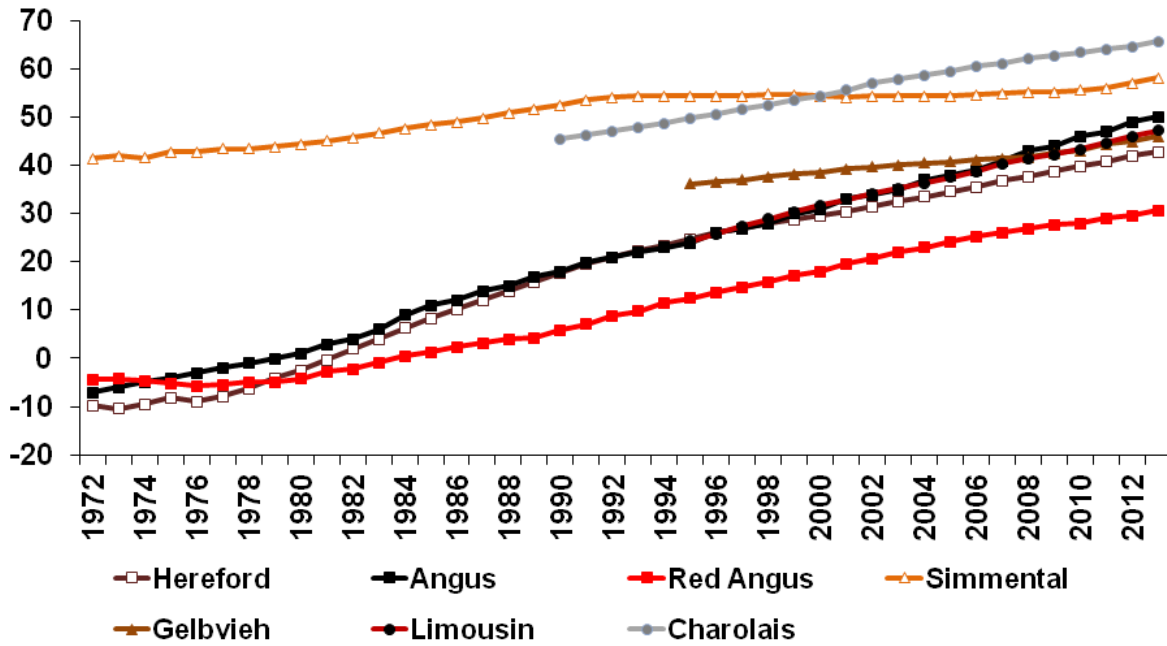


Figure 2. Relative genetic trends for weaning weight (lb) of the seven most highly used beef breeds (2a) and all breeds that submitted 2015 trends (2b) adjusted for birth year 2013 using the 2015 across-breed EPD adjustment factors.

2a.



2b.

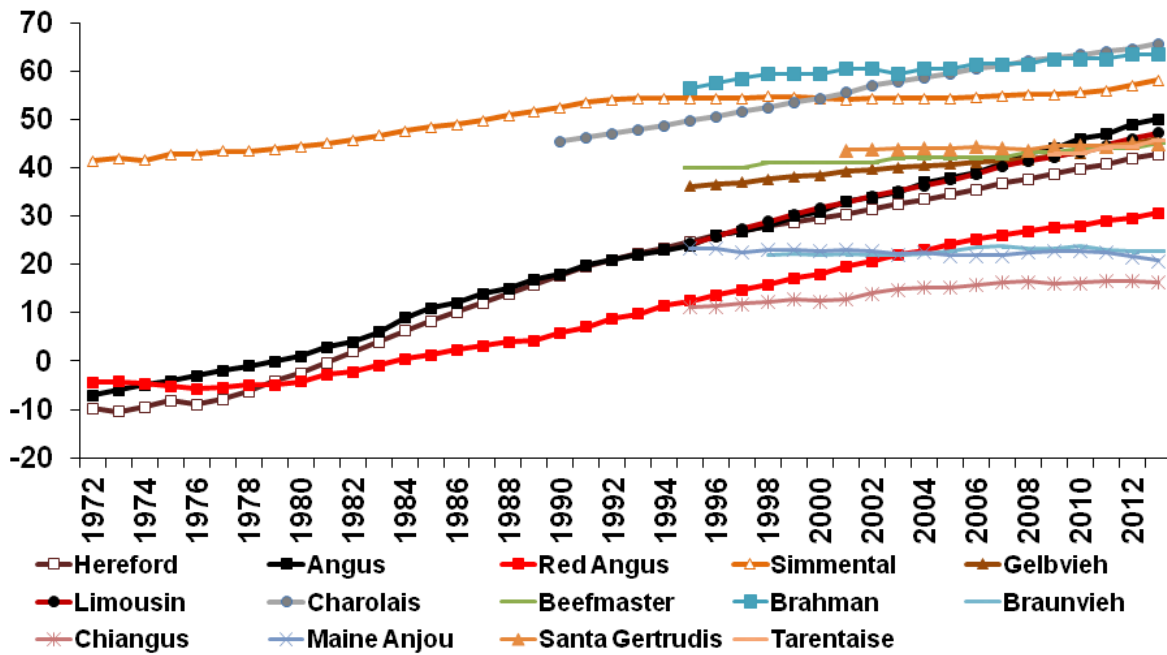
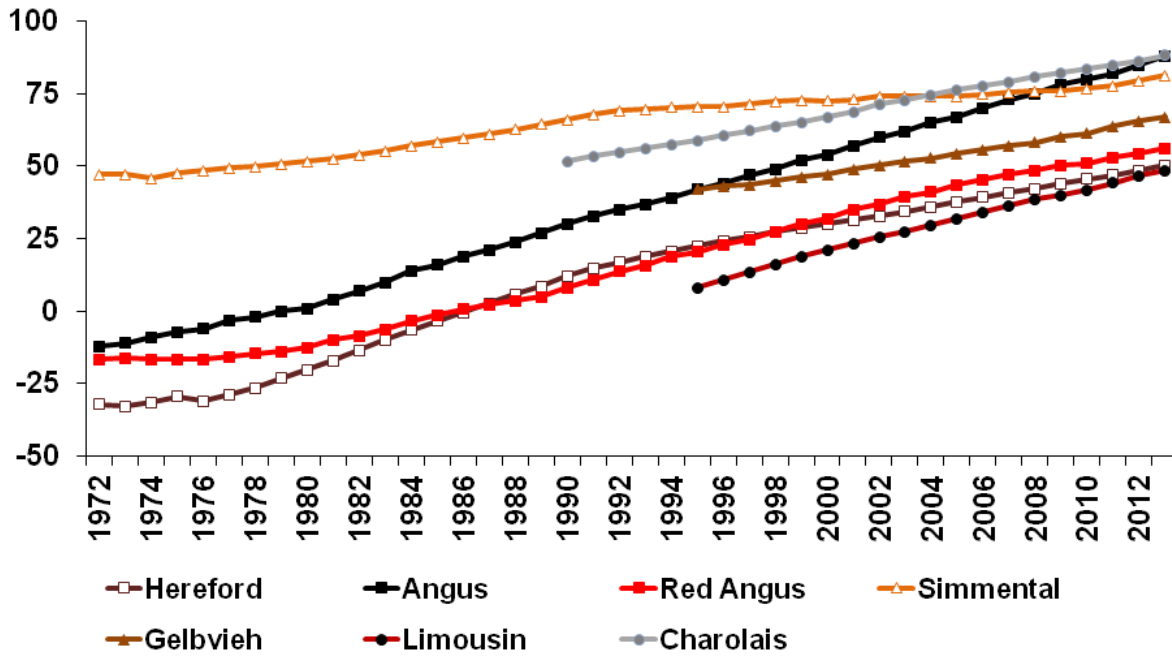


Figure 3. Relative genetic trends for yearling weight (lb) of the seven most highly used beef breeds (3a) and all breeds that submitted 2015 trends (3b) adjusted for birth year 2013 using the 2015 across-breed EPD adjustment factors.

3a.



3b.

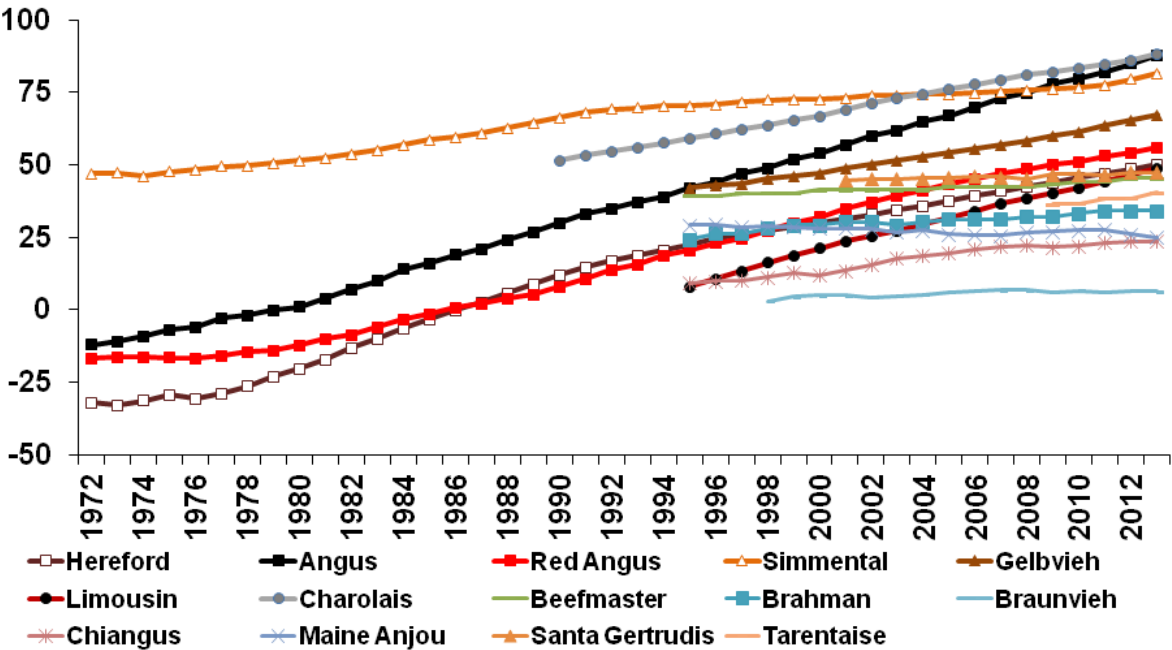
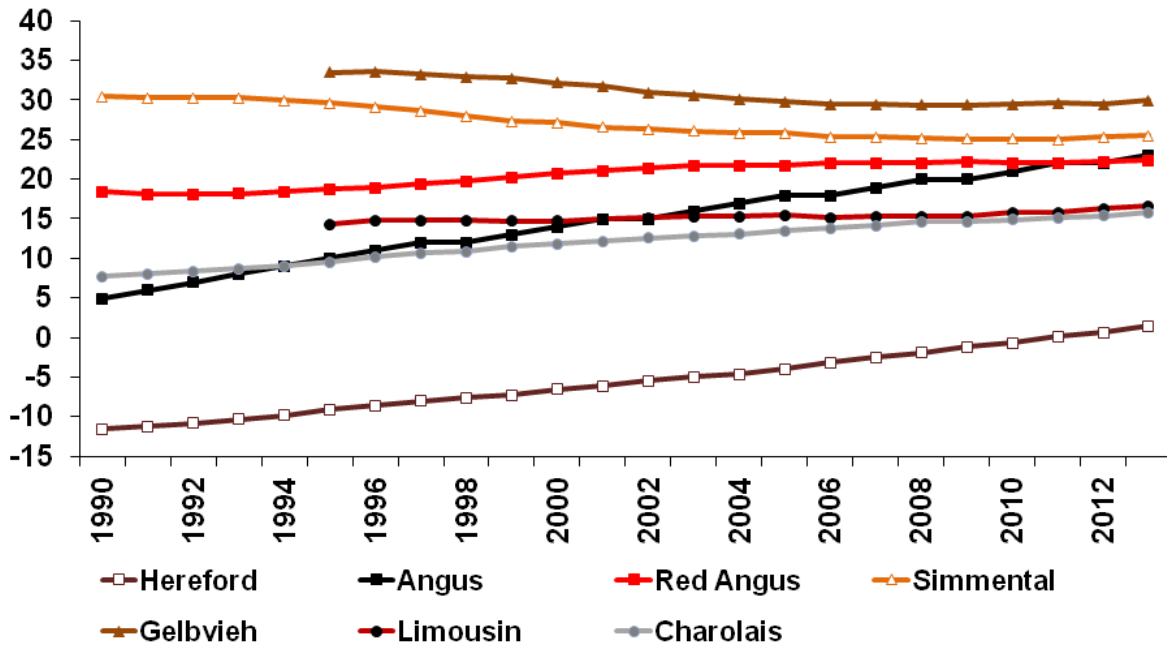
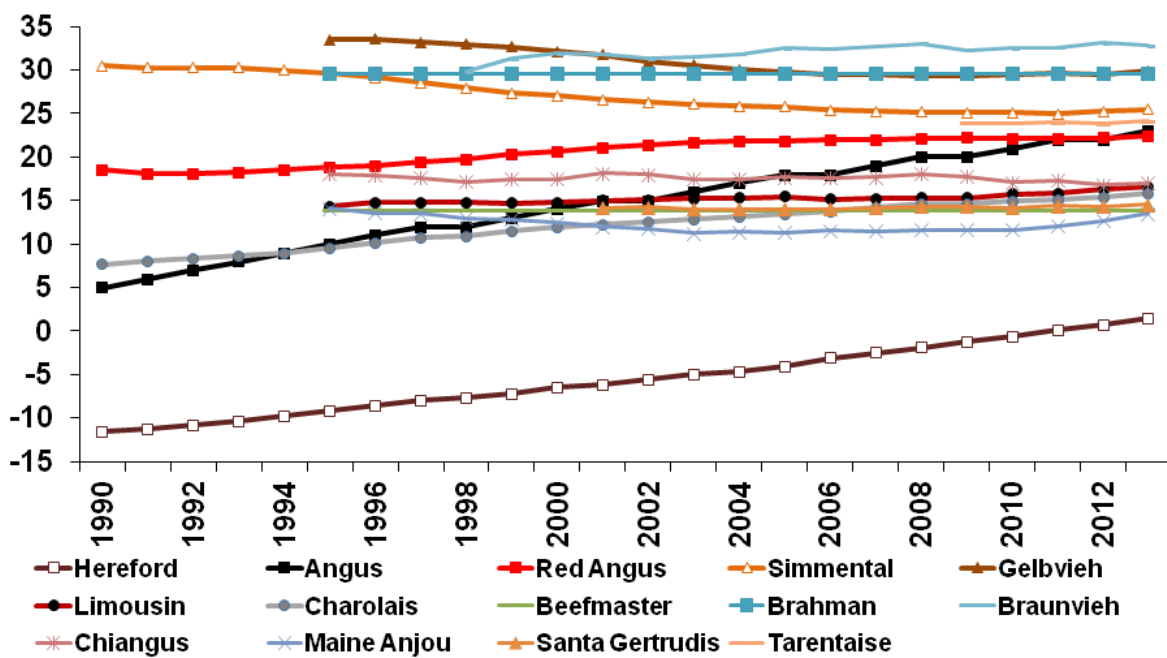


Figure 4. Relative genetic trends for maternal milk (lb) of the seven most highly used beef breeds (4a) and all breeds that submitted 2015 trends (4b) adjusted for birth year 2013 using the 2015 across-breed EPD adjustment factors.

4a.



4b.



Literature Cited

- Arnold, J. W., J. K. Bertrand, and L. L. Benyshek. 1992. Animal model for genetic evaluation of multibreed data. *J. Anim. Sci.* 70:3322-3332.
- Barkhouse, K. L., L. D. Van Vleck, and L. V. Cundiff. 1994. Breed comparisons for growth and maternal traits adjusted to a 1992 base. *Proc. Beef Improvement Federation 26th Research Symposium and Annual Meeting, Des Moines, IA, May, 1994.* pp 197-209.
- Barkhouse, K. L., L. D. Van Vleck, and L. V. Cundiff. 1995. Mixed model methods to estimate breed comparisons for growth and maternal traits adjusted to a 1993 base. *Proc. Beef Improvement Federation 27th Research Symposium and Annual Meeting, Sheridan, WY. May 31-June 3, 1995.* pp 218-239.
- Boldman, K. G., L. A. Kriese, L. D. Van Vleck, and S. D. Kachman. 1993. *A Manual for Use of MTDFREML (DRAFT)*. A set of programs to obtain estimates of variances and covariances. USDA-ARS, Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, NE. (120 pp).
- Cundiff, L. V. 1993. Breed comparisons adjusted to a 1991 basis using current EPD's. *Proc. Beef Improvement Federation Research Symposium and Annual Meeting, Asheville, NC. May 26-29, 1993.* pp 114-123.
- Cundiff, L. V. 1994. Procedures for across breed EPD's. *Proc. Fourth Genetic Prediction Workshop, Beef Improvement Federation, Kansas City, MO. Jan. 1994.*
- Koch, R. M., L. V. Cundiff, and K. E. Gregory. 1994. Cumulative selection and genetic change for weaning or yearling weight or for yearling weight plus muscle score in Hereford cattle. *J. Anim. Sci.* 72:864-885.
- Kuehn, L. A., L. D. Van Vleck, R. M. Thallman, and L. V. Cundiff. 2007. Across-breed EPD tables for the year 2007 adjusted to breed differences for birth year of 2005. *Proc. Beef Improvement Federation 39th Annual Research Symposium and Annual Meeting, Fort Collins, CO. June 6-9, 2007.* pp 74-92.
- Kuehn, L. A., L. D. Van Vleck, R. M. Thallman, and L. V. Cundiff. 2008. Across-breed EPD tables for the year 2008 adjusted to breed differences for birth year of 2006. *Proc. Beef Improvement Federation 40th Annual Research Symposium and Annual Meeting, Calgary, AB. June 30-July 3, 2008.* pp 53-74.
- Kuehn, L. A., L. D. Van Vleck, R. M. Thallman, and L. V. Cundiff. 2009. Across-breed EPD tables for the year 2009 adjusted to breed differences for birth year of 2007. *Proc. Beef Improvement Federation 41th Annual Research Symposium and Annual Meeting, Sacramento, CA. April 30-May 3, 2009.* pp 160-183.

- Kuehn, L. A., L. D. Van Vleck, R. M. Thallman, and L. V. Cundiff. 2010. Across-breed EPD tables for the year 2010 adjusted to breed differences for birth year of 2008. Proc. Beef Improvement Federation 42nd Annual Research Symposium and Annual Meeting, Columbia, MO. June 28-July 1, 2010. pp. 71-92.
- Kuehn, L. A., L. D. Van Vleck, R. M. Thallman, and L. V. Cundiff. 2011. Across-breed EPD tables for the year 2011 adjusted to breed differences for birth year of 2009. Proc. Beef Improvement Federation 43rd Annual Research Symposium and Annual Meeting, Bozeman, MT. June 1-4, 2011. pp. 92-111.
- Kuehn, L. A., and R. M. Thallman. 2012. Across-breed EPD tables for the year 2012 adjusted to breed differences for birth year of 2010. Proc. Beef Improvement Federation 44th Annual Research Symposium and Annual Meeting, Houston, TX. April 18-21, 2012. pp. 152-177.
- Kuehn, L. A., and R. M. Thallman. 2013. Across-breed EPD tables for the year 2013 adjusted to breed differences for birth year of 2011. Proc. Beef Improvement Federation 45th Annual Research Symposium and Annual Meeting, Oklahoma City, OK. June 12-15, 2013. pp. 114-141.
- Kuehn, L. A., and R. M. Thallman. 2014. Across-breed EPD tables for the year 2014 adjusted to breed differences for birth year of 2012. Proc. Beef Improvement Federation 46th Annual Research Symposium and Annual Meeting, Lincoln, NE. June 18-21, 2014. pp. 134-155.
- Notter, D. R., and L. V. Cundiff. 1991. Across-breed expected progeny differences: Use of within-breed expected progeny differences to adjust breed evaluations for sire sampling and genetic trend. *J. Anim. Sci.* 69:4763-4776.
- Núñez-Dominguez, R., L. D. Van Vleck, and L. V. Cundiff. 1993. Breed comparisons for growth traits adjusted for within-breed genetic trend using expected progeny differences. *J. Anim. Sci.* 71:1419-1428.
- Van Vleck, L. D. 1994. Prediction error variances for inter-breed EPD's. Proc. Fourth Genetic Prediction Workshop, Beef Improvement Federation, Kansas City, MO. Jan. 1994.
- Van Vleck, L. D., and L. V. Cundiff. 1994. Prediction error variances for inter-breed genetic evaluations. *J. Anim. Sci.* 71:1971-1977.
- Van Vleck, L. D., and L. V. Cundiff. 1995. Assignment of risk to across-breed EPDs with tables of variances of estimates of breed differences. Proc. Beef Improvement Federation 27th Research Symposium and Annual Meeting, Sheridan, WY. May 31-June 3, 1995. pp 240-245.

- Van Vleck, L. D., and L. V. Cundiff. 1997. Differences in breed of sire differences for weights of male and female calves. Proc. Beef Improvement Federation Research Symposium and Annual Meeting, Dickinson, ND. May 14-17, 1997. pp 131-137.
- Van Vleck, L. D., and L. V. Cundiff. 1997. The across-breed EPD tables adjusted to a 1995 base. Proc. Beef Improvement Federation Research Symposium and Annual Meeting, Dickinson, ND. May 14-17, 1997. pp 102-117.
- Van Vleck, L. D., and L. V. Cundiff. 1998. Across-breed EPD tables for 1998 adjusted to a 1996 base. Proc. Beef Improvement Federation Research Symposium and Annual Meeting, Calgary, Alberta, Canada. July 2, 1998. pp 196-212.
- Van Vleck, L. D., and L. V. Cundiff. 1998. Influence of breed of dam on across-breed adjustment factors. Midwestern Section ASAS and Midwest Branch ADSA 1998 Meeting, Des Moines, IA. Abstract # 10. p 31.
- Van Vleck, L. D., and L. V. Cundiff. 1999. Across-breed EPD tables for 1999 adjusted to a 1997 base. Proc. Beef Improvement Federation 31th Annual Research Symposium and Annual Meeting, Roanoke, VA. June 15-19, 1999. pp 155-171.
- Van Vleck, L. D., and L. V. Cundiff. 2000. Across-breed EPD tables for 2000 adjusted to a 1998 base. Proc. Beef Improvement Federation 32th Annual Research Symposium and Annual Meeting, Wichita, KS. July 12-15, 2000. pp 98-116.
- Van Vleck, L. D., and L. V. Cundiff. 2001. Across-breed EPD tables for 2001 adjusted to breed differences for birth year 1999. Proc. Beef Improvement Federation 33th Annual Research Symposium and Annual Meeting, San Antonio, TX. July 11-14, 2001. pp 44-63.
- Van Vleck, L. D., and L. V. Cundiff. 2002. Across-breed EPD tables for 2002 adjusted to breed differences for birth year of 2000. Proc. Beef Improvement Federation 34th Annual Research Symposium and Annual Meeting, Omaha, NE. July 10-13, 2002. pp 139-159.
- Van Vleck, L. D., and L. V. Cundiff. 2003. Across-breed EPD tables for the year 2003 adjusted to breed differences for birth year of 2001. Proc. Beef Improvement Federation 35th Annual Research Symposium and Annual Meeting, Lexington, KY. May 28-31, 2003. pp 55-63.
- Van Vleck, L. D., and L. V. Cundiff. 2004. Across-breed EPD tables for the year 2004 adjusted to breed differences for birth year of 2002. Proc. Beef Improvement Federation 36th Annual Research Symposium and Annual Meeting, Sioux Falls, SD. May 25-28, 2004. pp 46-61.
- Van Vleck, L. D., and L. V. Cundiff. 2005. Across-breed EPD tables for the year 2005 adjusted to breed differences for birth year of 2003. Proc. Beef Improvement Federation 37th

Annual Research Symposium and Annual Meeting, Billings, MT. July 6-9, 2005. pp 126-142.

Van Vleck, L. D., and L. V. Cundiff. 2006. Across-breed EPD tables for the year 2006 adjusted to breed differences for birth year of 2004. Proc. Beef Improvement Federation 39th Annual Research Symposium and Annual Meeting, Choctaw, MS. April 18-21, 2006. Available online at: <http://www.beefimprovement.org/content/uploads/2013/07/Across-Breed-EPD-Tables.pdf>.

Van Vleck, L. D., L. V. Cundiff, T. L. Wheeler, S. D. Shackelford, and M. Koohmaraie. 2007. Across-breed adjustment factors for expected progeny differences for carcass traits. J. Anim. Sci. 85:1369-1376.

Westell, R. A., R. L. Quaas, and L. D. Van Vleck. 1988. Genetic groups in an animal model. J. Dairy Sci. 71:1310-1318.