# Across-Breed EPD Tables for the Year 2004 Adjusted to Breed Differences for Birth Year of 2002

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## Introduction

This report is the year 2004 update of estimates of sire breed means from data of the Germplasm Evaluation (GPE) project at the U.S. Meat Animal Research Center (USMARC) adjusted to a year 2002 base using EPDs from the most recent national cattle evaluations. Factors to adjust EPD of 17 breeds to a common birth year of 2002 were calculated and reported in Tables 1-3 for birth weight, weaning weight, and yearling weight and in Table 4 for 15 breeds for the MILK component of maternal weaning weight.

Some changes from the 2003 update (Van Vleck and Cundiff, 2003) are as follows:

Records from USMARC for birth, weaning, and yearling weights were the same as last year with important exceptions that will be noted. The EPDs from the Limousin national cattle evaluations were computed with a new base which causes major changes in the across-breed adjustment factors for Limousin weights. A change in base and genetic parameters for Charolais EPD resulted in some changes in adjustment factors for Charolais weights. A change to a multibreed genetic evaluation by the American Salers Association resulted in some changes in adjustment factors for Salers weights.

A considerable number of maternal records (weaning weights of grandprogeny) were added this year, ranging from about 160 for Hereford and Angus to about 75 for Simmental, Limousin, Charolais, Gelbvieh, and Red Angus.

1) a) For BWT, a Beefmaster sire (1 of 21) with 9 calves (of 214) was added but resulted in little change in the across-breed adjustment.
   b) The new Limousin base resulted in a change in the across-breed adjustment factor from 5.8 to 4.5 lb.
2) For WWT, the USMARC records were the same as last year so that any changes from the analysis will be due to the EPD reported by the breed associations.
   a) The new Limousin base changed the adjustment factor from 23.5 to 1.8 lb.
   b) The new Charolais base and genetic parameters changed the adjustment factor
   factor from 41.1 to 38.4 lb.
   c) The Salers adjustment factor changed nearly as much. The change follows that seen last year as the 2002, 2003, 2004 across-breed adjustments were: 26.1 to 28.4 to 30.7 lb in the 2004 update.
3) Last year, due to the earlier deadline for reports to be included in the BIF proceedings, weights taken at USMARC in 2003 which were converted to yearling weights were taken in mid-March rather than as usual in mid-April. This year no new yearling records were added to USMARC data but the mid-April weights for 2003 were available and were used to calculate yearling weights for the 2004 update. The breeds affected were Hereford, Angus, Brangus and Beefmaster. Hereford and Angus were affected slightly because the 2003 records comprised only a small proportion of their yearling weight records. The impact was greater for Brangus and Beefmaster because one-half of their YWT records were obtained in 2003.
   a) The effect of the warmer month was to add 7 to 10 lb to the solutions for Beefmaster and Brangus compared with the base breed of Angus. The new solutions changed the across-breed adjustments from 11.1 to 20.4 lb for Brangus and from 29.7 to 37.9 lb for Beefmaster. The yearling weights of two Brangus and three Beefmaster calves which were removed this year and which should have been removed last year, would also have contributed to the increases of about 20 lb for the unadjusted averages of both breeds.
   b) The new Limousin base resulted in a change in the across-breed adjustment from 20.5 to -19.9 lb.
   c) The changes in the Charolais NCE resulted in the adjustment changing from 57.8 to 53.4 lb.
   d) As with weaning weight for Salers, the adjustment factor for yearling weight also changed; from 40.6 to 46.1 lb.
4) a) About 160 maternal weaning weights for both Hereford and Angus grandsires and about 75 for Simmental, Limousin, Charolais, Gelbvieh and Red Angus grandsires were added to the maternal (MILK). Changes in the across-breed adjustments were not large except for that due to the Limousin base change: from 0.2 to -15.9 lb for Limousin, 3.8 to 1.7 lb for Gelbvieh, 11.3 to 9.0 lb for Salers, and -10.7 to -7.8 lb for Red Angus.
   b) The first crop of Brangus and Beefmaster sired heifers had calves with weaning weights available this year but the numbers (about 20 of each) were

considered too small to analyze this year as half of the heifers had been moved to an experiment in Louisiana.

The across-breed table adjustments apply **only** to EPDs for most recent (in most cases; spring, 2004) national cattle evaluations. Serious biases can occur if the table adjustments are used with earlier EPDs which may have been calculated with a different within-breed base.

## Materials and Methods

***Adjustment for heterosis***

The philosophy underlying the calculations has been that bulls compared using the across-breed adjustment factors will be used in a crossbreeding situation. Thus calves and cows would generally exhibit 100% of both direct and maternal heterozygosity for the MILK analysis and 100% of direct heterozygosity for the BWT, WWT, and YWT analyses. The use of the MARC III composite (1/4 each of Pinzgauer, Red Poll, Hereford, and Angus) as a dam breed for Angus, Brangus, Hereford and Red Angus sires requires a small adjustment for level of heterozygosity for analyses of calves for BWT, WWT and YWT and for cows for maternal weaning weight. Some sires (all multiple sire pasture mated) mated to the F1 cows are also crossbred so that adjustment for direct heterozygosity for the maternal analysis is required. Two approaches for accounting for differences in breed heterozygosity have been tried which resulted in similar final table adjustments. One approach was to include level of heterozygosity in the statistical models which essentially adjusts to a basis of no heterozygosity. The other approach was based on the original logic that bulls will be mated to another breed or line of dam so that progeny will exhibit 100% heterozygosity. Most of the lack of heterozygosity in the data results from homozygosity of Hereford or Angus genes from pure Hereford or Angus matings and also from Red Angus by Angus and from Hereford, Angus or Red Angus sires mated with MARC III composite dams (1/4 each, Pinzgauer, Red Poll, Hereford, and Angus). Consequently, the second approach was followed with estimates of heterosis obtained from analyses of BWT, WWT, YWT, and MWWT using only records from the imbedded diallel experiments with Hereford and Angus. Red Angus by Angus matings were assumed not to result in heterosis. With Brangus representing 5/8 and 3/8 inheritance from Angus and Brahman genes, records of Brangus sired calves were also adjusted to a full F1 basis when dams were Angus cows and MARC III cows (1/4 Angus). The adjustment for calves with Beefmaster (1/2 Brahman, 1/4 Shorthorn, 1/4 Hereford) sires was only when dams were MARC III cows (1/4 Hereford) as Beefmaster sires were not mated to Hereford cows.

The steps were:

1) Analyze records from H-A diallel experiments to estimate direct heterosis effects for BWT, WWT, YWT (1,326, 1,279, and 1,249 records for BWT, WWT, and YWT, respectively, representing 152 sires). The H-A diallel experiments were conducted as part of Cycle I (1970-1972 calf crops), Cycle II (1973-1974), Cycle IV (1986-1990) and Cycle VII (1999-2001) of the GPE program at MARC.
2) Adjust maternal weaning weight (MWWT) records of calves of the H-A cows from the diallel for estimates of direct heterosis from 1) and then estimate maternal heterosis effects from 3,255 weaning weight records of 776 daughters representing 171 Hereford and Angus maternal grandsires.
3) Adjust all records used for analyses of BWT, WWT and YWT for lack of direct heterozygosity using estimates from 1), and
4) Adjust all records used for analysis of MWWT for lack of both direct and maternal heterozygosity using estimates from 1) and 2).

Models for the analyses to estimate heterosis were the same as for the across-breed analyses with the obvious changes in breed of sire and breed of dam effects.

Estimates of direct heterosis were 3.01, 14.70, and 30.39 lb for BWT, WWT and YWT, respectively. The estimate of maternal heterosis was 23.05 lb for MWWT. As an example of step 3), birth weight of an H by H calf would have 3.01 added. A Red Angus by MARC III calf would have (1/4) (3.01) added to its birth weight. A Red Poll sired calf of an Angus by MARC III dam would have (1/8) (14.70) plus (1/4) (23.05) added to its weaning weight record to adjust to 100% heterozygosity for both direct and maternal components of weaning weight.

After these adjustments, all calculations were as outlined in the 1996 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), and Van Vleck and Cundiff (1997–2003). All calculations were done with programs written in Fortran language with estimates of variance components, regression coefficients, and breed effects obtained with 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 EPDs are relative to Angus.

For completeness, the basic steps in the calculations will be repeated.

***Models for Analysis of MARC Records***

Fixed effects in the models for birth weight, weaning weight (205-d) and yearling weight (365-d) were: breed of sire (17), dam line (Hereford, Angus, MARC III composite) by sex (female, male) by age of dam (2, 3, 4, 5-9, ≥10 yr) combination (49), year of birth (21) of dam (1970-76, 86-90, 92-94 and 97-99, 2000-02) by damline combination (101) and a separate covariate for day of year at birth of calf for each of the three breeds of dam. Cows from the Hereford selection lines were used in Cycle IV of GPE. To account for differences from the original Hereford cows, Hereford dams were subdivided into the selection lines and others. That refinement of the model had little effect on breed of sire solutions. Dam of calf was included as a random effect to account for correlated maternal effects for cows with more than one calf (4,630 dams for BWT, 4,395 for WWT, 4,243 for YWT). For estimation of variance components and to estimate breed of sire effects, sire of calf was also used as a random effect (650).

Variance components were estimated with a derivative-free REML algorithm. At convergence, the breed of sire solutions were obtained as were the sampling variances of the estimates to use in constructing prediction error variances for pairs of bulls of different breeds.

For estimation of coefficients of regression of progeny performance on EPD of sire, the random sire effect was dropped from the model. Pooled regression coefficients, and regression coefficients by sire breed, by dam line, and by sex of calf were obtained. These regression coefficients are monitored as accuracy checks and for possible genetic by environment interactions. The pooled regression coefficients were used as described later to adjust for genetic trend and bulls used at MARC.

The fixed effects for the analysis of maternal effects included breed of maternal grandsire (15), maternal granddam line (Hereford, Angus, MARC III), breed of natural service mating sire (17), sex of calf (2), birth year-GPE cycle-age of dam subclass (79), and mating sire breed by GPE cycle by age of dam subclass (43) with a covariate for day of year of birth. The subclasses are used to account for confounding of years, mating sire breeds, and ages of dams. Ages of dam classes were (2, 3, 4, 5-9, ≥10 yr). For estimation of variance components and estimation of breed of maternal grandsire effects, random effects were maternal grandsire (573) and dam (3,017 daughters of the maternal grandsires). Mating sires were unknown within breed. For estimation of regression coefficients of grandprogeny weaning weight on maternal grandsire EPD for weaning weight and milk, random effects of both maternal grandsire and dam (daughter of MGS) were dropped from the model.

***Adjustment of MARC Solutions***

The calculations of across-breed adjustment factors rely on solutions for breed of sire or breed of maternal grandsire from records at MARC and on averages of within-breed EPDs. The records from MARC are not used in calculation of within-breed EPD by the breed associations. The basic calculations for BWT, WWT, and YWT are as follows:

MARC breed of sire solution adjusted for genetic trend (as if bulls born in the base year had been used rather than the bulls actually used).

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

Breed table factor to add to the EPD for a bull of breed i:

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

where,

MARC(i) is solution from mixed model equations with MARC data for sire breed i,

$EPD(i)_{YY}$ is the average within-breed EPD for breed i for animals born in the base year (YY, which is two years before the update; e.g., YY = 2002 for the 2004 update),

$EPD(i)_{MARC}$ is the weighted (by number of progeny at MARC)

average of EPD of bulls of breed i having progeny with records at MARC,

b is the pooled coefficient of regression of progeny performance at MARC on EPD of sire (for 2004: 1.05, 0.86, and 1.13 for BWT, WWT, YWT),

i denotes sire breed i, and

x denotes the base breed, which is Angus in this report.

The calculations to arrive at the Breed Table Factor for milk are more complicated because of the need to separate the direct effect of the maternal grandsire breed from the maternal (milk) effect of the breed.

MARC breed of maternal grandsire solution for WWT adjusted for genetic trend:

$$MWWT(i) = MARC(i)_{MGS} + b_{wwt}[EPD(i)_{YYWWT} - EPD(i)_{MARCWWT}] + b_{MLK}[EPD(i)_{YYMLK} - EPD(i)_{MARCMLK}]$$

MARC breed of maternal grandsire solution adjusted for genetic trend and direct genetic effect:

$$MILK(i) = [MWWT(i) - 0.5\ M(i)] - [\overline{MWWT} - 0.5\ \overline{M}]$$

Breed table factor to add to EPD for MILK for bull of breed i:

$$A_i = [MILK(i) - MILK(x)] - [EPD(i)_{YYMLK} - EPD(i)_{MARCMLK}]$$

where,

$MARC(i)_{MGS}$ is solution from mixed model equations with MARC data for MGS breed i for WWT,

$EPD(i)_{YYWWT}$ is the average within-breed EPD for WWT for breed i for animals born in base year (YY),

$EPD(i)_{MARCWWT}$ is the weighted (by number of grandprogeny at MARC) average of EPD for WWT of MGS of breed i having grandprogeny with records at MARC,

$EPD(i)_{YYMLK}$ is the average within-breed EPD for MILK for breed i for animals born in base year (YY),

$EPD(i)_{MARCMLK}$ is the weighted (by number of grandprogeny at MARC) average of EPD for MILK of MGS of breed i having grandprogeny with records at MARC,

$b_{WWT}$, $b_{MLK}$ are the coefficients of regression of performance of MARC grandprogeny on MGS EPD for WWT and MILK (for 2004: 0.59 and 1.13),

$M(i) = M_i$ is the MARC breed of sire solution from the first analysis of direct breed of sire effects for WWT adjusted for genetic trend,

$\overline{MWWT}$ and $\overline{M}$ are unneeded constants corresponding to unweighted averages of MWWT(i) and M(i) for i = 1,..., n, the number of sire (maternal grandsire) breeds included in the analysis.

## Results

Tables 1, 2, and 3 (for BWT, WWT and YWT) summarize the data from, and results of, MARC analyses to estimate breed of sire differences and the adjustments to the breed of sire effects to a year 2002 base. The last column of each table corresponds to the "breed table" factor for that trait.

The general result shown in Tables 1-4 is that many breeds are continuing to become more similar to the arbitrary base breed, Angus. Most of the other breeds have not changed much relative to each other. Column 7 of Tables 1-3 and column 10 of Table 4 represent the best estimates of breed differences for calves born in 2002. These pairs of differences minus the corresponding differences in average EPD for animals born in 2002 result in the last column of the tables to be used as adjustment factors for pairs of sires with within-breed EPD.

***Birth Weight***

The range in estimated breed of sire differences for BWT relative to Angus is large: from 1.5 lb for Red Angus to 9.4 lb for Charolais and 12.5 lb for Brahman. The relatively heavy birth weights of Brahman sired progeny would be expected to be completely 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. Differences from Angus were only slightly changed from the 2003 update but most of the changes were generally to slightly smaller differences from Angus.

Suppose the EPD for birth weight for a Charolais bull is +2.0 (which is above the year 2002 average of 1.5 for Charolais) and for a Hereford bull is also +2.0 (which is below the year 2002 average of 3.8 for Herefords). The across-breed adjustment factors in the last column of Table 1 are 3.5 for Hereford and 10.5 for Charolais. Then the adjusted EPD for the Charolais bull is 10.5 + 2.0 = 12.5 and for the Hereford bull is 3.5 + 2.0 = 5.5. The expected birth weight difference when both are mated to another breed of cow, e.g., Angus, would be 12.5 - 5.5 = 7.0 lb.

***Weaning Weight***

Weaning weights also seem to be becoming more similar for the breeds when used as sire breeds. Most of the changes between the year 2003 and 2004 updates were less than 2 lb. All except three sire breed means for WWT adjusted to year of birth of 2002 are within about 10 lb of the Angus mean.

**Yearling Weight**

Changes in adjusted differences from Angus from the 2003 update were generally small: 1 to 2 lb. The major exceptions were for Brangus and Beefmaster where two and three records which should have been removed from the data base last year were removed this year. More importantly, April weights rather than March weights were available for use this year for the 2002 calf crop which would be less affected by adverse effects of cold weather on postweaning growth rate of progeny with Brahman influenced sires. The result was that the adjusted differences from Angus for the current base year went from -18.4 to -11.1 lb for Brangus and from -22.2 to -16.0 lb for Beefmaster. Adjusted to a base year of 2002, Angus have heavier yearling weights than 11 breeds (11.1 to 44.1 lb), lighter yearling weights than 2 breeds (14.7 and 20.4 lb) and nearly the same as 3 breeds (-0.7 to 0.1 lb).

***Milk***

The greatest changes from last year for MILK compared to Angus for the current base year were for breeds that added about 75 grandprogeny: -3.5, -2.7, -2.7, and +3.0 lb for Limousin, Charolais, Gelbvieh, and Red Angus, respectively. Red Angus added 74 records to the previous

112 records. The other 3 breeds generally added less than 10% more maternal weaning weight records. The comparison of Hereford and Angus changed very little although both added about 160 weaning weights to the analysis for milk. For MILK with breeds adjusted to the current base year, Angus were within 2.3 lb of 4 breeds, exceeded 8 breeds (2.9 to 15.2 lb) and trailed only 2 breeds (4.8 for Braunvieh and 15.0 lb for Brahman). The greatest changes in the across-breed adjustment factors were for Limousin which has changed its base and for Red Angus which changed somewhat due to the additional grandprogeny weaning weights.

Table 5 summarizes the average BIF accuracy for bulls with progeny at MARC weighted appropriately by number of progeny or grandprogeny. South Devon bulls had relatively small accuracy for all traits as did Hereford, Brahman, and Maine-Anjou bulls. Braunvieh bulls had low accuracy for milk. The accuracy values for Brangus are relatively high. Table 6 reports the estimates of variance components from the records that were used in the mixed model equations to obtain breed of sire and breed of MGS solutions. Neither Table 5 nor Table 6 changed much from the 2003 report.

Table 7 updates the coefficients of regression of records of MARC 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 1.05 for BWT, 0.86 for WWT, and 1.13 for YWT were used to adjust breed of sire solutions to the base year of 2002. These regression coefficients are reasonably close to expected values of 1.0. Deviations from 1.0 are believed to be due to scaling differences between performance of progeny in the MARC herd and of progeny in herds contributing to the national genetic evaluations of the 17 breeds.

The regression coefficient for female progeny on sire EPD for YWT was 0.93 compared to 1.30 for steers. These differences are probably expected because postweaning average daily gains for heifers have been significantly less than those for steers. The females were fed relatively high roughage diets to support average daily gains of 1.6 lb per day while the steers were fed relatively high energy growing and finishing diets supporting average daily gains of about 3.4 lb per day. For reasons that have never been clear, the regressions for sex used to fluctuate widely from year to year, but for the past six years the pattern has been fairly consistent (female estimates have ranged from 0.93 to 1.02; while male estimates have ranged from 1.26 to 1.32).

The coefficients of regression of records of grandprogeny on MGS EPD for WWT and MILK are shown in Table 8. Several sire (MGS) breeds have regression coefficients considerably different from the theoretical expected values of 0.50 for WWT and 1.00 for MILK. The standard errors for the regression coefficients by breed are large except for Angus and Hereford. The standard errors for regression coefficients over all breeds of grandsires associated with heifers and steers overlap for milk EPD. Again, the pooled regression coefficients of 0.59 for MWWT and 1.13 for MILK are reasonably close to the expected regression coefficients of 0.50 and 1.00, respectively.

***Prediction Error Variances of Across-Breed EPD***

The standard errors of differences in the solutions for breed of sire and breed of MGS differences from the MARC records can be adjusted by theoretical approximations to obtain variances of adjusted breed differences (Van Vleck, 1994; Van Vleck and Cundiff, 1994). These variances of estimated breed differences can be added to prediction error variances of within-breed EPDs to obtain prediction error variances (PEV) or equivalently standard errors of prediction (SEP) for across-breed EPDs (Van Vleck and Cundiff 1994, 1995). The variances of adjusted breed differences are given in the upper triangular part of Table 9 for BWT, lower triangular part of Table 9 for YWT, upper triangular part of Table 10 for direct WWT, and lower triangular part of Table 10 for MILK. How to use these to calculate standard errors of prediction for expected progeny differences of pairs of bulls of the same or different breeds was discussed in the 1995 BIF proceedings (Van Vleck and Cundiff, 1995).

Even though the variances of estimates of adjusted breed differences look large, especially for YWT and MILK, they generally contribute a relatively small amount to standard errors of predicted differences. For example, suppose for WWT, a Salers bull has an EPD of 15.0 with prediction error variance of 75 and a Hereford bull has an EPD of 30.0 with PEV of 50. The difference in predicted progeny performance is (Salers adjustment + Salers bull's EPD) - (Hereford adjustment + Hereford bull's EPD):

(30.7 + 15.0) - (-2.0 + 30.0) = 45.7 – 28.0 = 17.7.

The prediction error variance for this difference is (use the 18.0 in the upper part of Table 10 at intersection of row for HE and column for SA):

V(Salers breed - Hereford breed) + PEV(Salers bull) + PEV(Hereford bull):

18 + 75 + 50 = 143

with

standard error of prediction, $\sqrt{143} = 12$.

If the difference between the Salers and Hereford breeds in the year 2002 could be estimated perfectly, the

variance of the estimate of the breed difference would be 0 and the standard error of prediction between the two bulls would be:

$\sqrt{0+75+50} = 11.2$ which is only slightly smaller than 12.0.

## Implications

Bulls of different breeds can be compared on a common EPD scale by adding the appropriate table factor to expected progeny differences (EPDs) produced in the most recent genetic evaluations for each of the 17 breeds. The across-breed EPDs are most useful to commercial producers purchasing bulls of two or more breeds to use in systematic crossbreeding programs. Uniformity in across-breed EPDs should be emphasized for rotational crossing. Divergence in across-breed EPDs 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 EPDs depends primarily upon the accuracy of the within-breed EPDs of individual bulls being compared.

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**Table 1.** Breed of sire solutions from MARC, mean breed and MARC EPDs used to adjust for genetic trend to 2002 base and factors to adjust within breed EPDs to Angus equivalent - BIRTH WEIGHT (lb)

| | Number | | Raw MARC Mean | Ave. Base EPD Breed 2002 | Ave. Base EPD MARC Bulls | Breed Soln at MARC + Ang vs Ang | | Adjust to 2002 Base + Ang vs Ang | | Factor to adjust EPD to Angus |
|---|---|---|---|---|---|---|---|---|---|---|
| Breed | Sires | Progeny | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Hereford | 113 | 1817 | 87 | 3.8 | 2.4 | 88 | 3.6 | 89 | 4.6 | 3.4 |
| Angus | 105 | 1421 | 84 | 2.6 | 2.2 | 84 | 0.0 | 84 | 0.0 | 0.0 |
| Shorthorn | 25 | 181 | 87 | 1.8 | 0.9 | 90 | 6.4 | 91 | 7.0 | 7.8 |
| South Devon | 15 | 153 | 80 | 0.0 | -0.2 | 88 | 4.3 | 89 | 4.1 | 6.7 |
| Brahman | 40 | 589 | 98 | 2.1 | 0.7 | 96 | 11.6 | 97 | 12.5 | 13.0 |
| Simmental | 48 | 623 | 87 | 1.9 | 2.7 | 91 | 7.0 | 90 | 5.7 | 6.4 |
| Limousin | 40 | 589 | 83 | 2.4 | 0.7 | 87 | 3.0 | 89 | 4.3 | 4.5 |
| Charolais | 75 | 675 | 89 | 1.5 | 0.5 | 93 | 8.8 | 94 | 9.4 | 10.5 |
| Maine-Anjou | 18 | 218 | 94 | 2.5 | 5.9 | 95 | 10.6 | 91 | 6.6 | 6.7 |
| Gelbvieh | 48 | 595 | 89 | 1.0 | 0.9 | 88 | 4.1 | 88 | 3.8 | 5.4 |
| Pinzgauer | 16 | 435 | 84 | -0.1 | -0.4 | 89 | 5.2 | 89 | 5.0 | 7.7 |
| Tarentaise | 7 | 199 | 80 | 2.2 | 1.8 | 87 | 3.2 | 88 | 3.2 | 3.6 |
| Salers | 27 | 189 | 85 | 1.1 | 1.7 | 88 | 4.4 | 88 | 3.4 | 4.9 |
| Red Angus | 21 | 206 | 85 | 0.5 | -0.7 | 85 | 0.6 | 86 | 1.5 | 3.6 |
| Braunvieh | 7 | 188 | 88 | 1.1 | 0.8 | 89 | 5.1 | 89 | 5.0 | 6.5 |
| Brangus | 21 | 215 | 91 | 2.0 | 2.4 | 90 | 5.9 | 90 | 5.1 | 5.7 |
| Beefmaster | 21 | 214 | 96 | 0.4 | 0.8 | 92 | 8.3 | 92 | 7.5 | 9.7 |

Calculations:
(4) = (5) + (1, Angus)
(6) = (4) + b[(2) - (3)] with b = 1.05
(7) = (6) - (6, Angus)
(8) = (7) - (7, Angus) - [(2) - (2, Angus)]

**Table 2.** Breed of sire solutions from MARC, mean breed and MARC EPDs used to adjust for genetic trend to 2002 base and factors to adjust within breed EPDs to Angus equivalent - WEANING WEIGHT (lb)

| | Number | | Raw MARC Mean | Ave. Base EPD Breed 2002 | Ave. Base EPD MARC Bulls | Breed Soln at MARC + Ang vs Ang | | Adjust to 2002 Base + Ang vs Ang | | Factor to adjust EPD to Angus |
|---|---|---|---|---|---|---|---|---|---|---|
| Breed | Sires | Progeny | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Hereford | 112 | 1712 | 503 | 35.0 | 22.5 | 501 | -2.7 | 512 | -2.0 | -2.0 |
| Angus | 106 | 1315 | 504 | 35.0 | 23.3 | 504 | 0.0 | 514 | 0.0 | 0.0 |
| Shorthorn | 25 | 170 | 521 | 13.0 | 6.7 | 518 | 14.1 | 523 | 9.4 | 31.4 |
| South Devon | 15 | 134 | 443 | 17.1 | 0.2 | 503 | -0.6 | 518 | 3.8 | 21.7 |
| Brahman | 40 | 509 | 532 | 16.1 | 4.6 | 520 | 16.1 | 530 | 15.9 | 34.8 |
| Simmental | 47 | 564 | 505 | 33.6 | 23.5 | 526 | 22.4 | 535 | 21.0 | 22.4 |
| Limousin | 40 | 533 | 477 | 33.8 | 20.4 | 503 | -0.8 | 514 | 0.6 | 1.8 |
| Charolais | 74 | 600 | 514 | 18.2 | 8.5 | 527 | 23.3 | 535 | 21.6 | 38.4 |
| Maine-Anjou | 18 | 197 | 459 | 15.9 | 23.6 | 519 | 15.1 | 513 | -1.5 | 17.6 |
| Gelbvieh | 48 | 559 | 507 | 36.4 | 31.4 | 518 | 14.3 | 522 | 8.5 | 7.1 |
| Pinzgauer | 16 | 415 | 478 | 0.6 | -4.1 | 504 | -0.1 | 508 | -6.1 | 28.3 |
| Tarentaise | 7 | 191 | 476 | 12.0 | -4.8 | 507 | 2.7 | 521 | 7.1 | 30.1 |
| Salers | 27 | 176 | 525 | 12.0 | 5.0 | 516 | 11.7 | 522 | 7.7 | 30.7 |
| Red Angus | 21 | 199 | 535 | 28.0 | 27.2 | 505 | 1.0 | 506 | -8.4 | -1.4 |
| Braunvieh | 7 | 183 | 451 | 6.6 | 7.0 | 516 | 12.0 | 516 | 1.6 | 30.0 |
| Brangus | 21 | 208 | 550 | 20.9 | 26.1 | 524 | 20.3 | 520 | 5.9 | 20.0 |
| Beefmaster | 22 | 215 | 563 | 6.0 | 13.3 | 530 | 26.3 | 524 | 10.0 | 39.0 |

Calculations:
(4) = (5) + (1, Angus)
(6) = (4) + b[(2) - (3)] with b = 0.86
(7) = (6) - (6, Angus)
(8) = (7) - (7, Angus) - [(2) - (2, Angus)]

**Table 3.** Breed of sire solutions from MARC, mean breed and MARC EPDs used to adjust for genetic trend to 2002 base and factors to adjust within breed EPDs to Angus equivalent - YEARLING WEIGHT (lb)

| | Number | | Raw MARC Mean | Ave. Base EPD Breed 2002 | Ave. Base EPD MARC Bulls | Breed Soln at MARC + Ang vs Ang | | Adjust to 2002 Base + Ang vs Ang | | Factor to adjust EPD to Angus |
|---|---|---|---|---|---|---|---|---|---|---|
| Breed | Sires | Progeny | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Hereford | 112 | 1627 | 852 | 60.0 | 38.4 | 852 | -20.0 | 876 | -18.7 | -13.7 |
| Angus | 106 | 1257 | 872 | 65.0 | 44.4 | 872 | 0.0 | 895 | 0.0 | 0.0 |
| Shorthorn | 25 | 168 | 918 | 20.0 | 13.2 | 887 | 15.0 | 895 | -0.5 | 44.5 |
| South Devon | 15 | 134 | 744 | 23.5 | 0.3 | 868 | -3.7 | 894 | -0.7 | 40.8 |
| Brahman | 40 | 438 | 838 | 26.3 | 8.4 | 832 | -40.1 | 852 | -43.1 | -4.4 |
| Simmental | 47 | 528 | 852 | 57.8 | 39.0 | 889 | 16.7 | 910 | 14.7 | 21.9 |
| Limousin | 40 | 527 | 797 | 63.5 | 41.2 | 849 | -23.3 | 874 | -21.4 | -19.9 |
| Charolais | 74 | 566 | 882 | 32.0 | 15.6 | 897 | 25.1 | 916 | 20.4 | 53.4 |
| Maine-Anjou | 18 | 196 | 787 | 31.1 | 46.6 | 884 | 12.3 | 867 | -28.4 | 5.5 |
| Gelbvieh | 48 | 555 | 849 | 68.9 | 56.7 | 864 | -7.8 | 878 | -17.2 | -21.1 |
| Pinzgauer | 16 | 347 | 838 | 0.7 | -8.0 | 847 | -25.3 | 856 | -38.8 | 25.5 |
| Tarentaise | 7 | 189 | 807 | 23.0 | -3.4 | 837 | -35.2 | 867 | -28.6 | 13.4 |
| Salers | 27 | 173 | 899 | 19.0 | 5.3 | 880 | 7.8 | 895 | 0.1 | 46.1 |
| Red Angus | 21 | 194 | 916 | 48.0 | 46.7 | 877 | 5.4 | 879 | -16.3 | 0.7 |
| Braunvieh | 7 | 182 | 737 | 7.0 | 10.9 | 856 | -16.4 | 851 | -44.1 | 13.9 |
| Brangus | 21 | 152 | 977 | 33.5 | 44.2 | 896 | 24.1 | 884 | -11.1 | 20.4 |
| Beefmaster | 22 | 157 | 991 | 11.1 | 23.3 | 893 | 20.9 | 879 | -16.0 | 37.9 |

Calculations:
(4) = (5) + (1, Angus)
(6) = (4) + b[(2) - (3)] with b = 1.13
(7) = (6) - (6, Angus)
(8) = (7) - (7, Angus) - [(2) - (2, Angus)]

**Table 4.** Breed of maternal grandsire solutions from MARC, mean breed and MARC EPDs used to adjust for genetic trend to 2002 base and factors to adjust within-breed EPDs to Angus equivalent - MILK (lb)

| | | Number | | Raw MARC Mean | Mean EPD Breed | | MARC | | Breed Soln at MARC MWWT + Ang vs Ang | | Adjust to 2002 Base MWWT + Ang vs Ang | MILK | Factor to Adjust MILK EPD to Angus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Breed | MGS | Gpr | Daughters | (1) | WWT (2) | MILK (3) | WWT (4) | MILK (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| Hereford | 103 | 2565 | 668 | 473 | 35.0 | 13.0 | 19.4 | 6.1 | 470 | -19.5 | 487 | -22.8 | -17.7 | -17.8 |
| Angus | 101 | 1826 | 488 | 490 | 35.0 | 17.0 | 17.7 | 8.1 | 490 | 0.0 | 510 | 0.0 | 4.1 | 0.0 |
| Shorthorn | 22 | 251 | 69 | 527 | 13.0 | 2.0 | 6.7 | 7.0 | 514 | 24.0 | 512 | 1.8 | 1.2 | 12.1 |
| South Devon | 14 | 347 | 69 | 488 | 17.1 | 6.2 | 0.1 | 5.4 | 494 | 4.0 | 505 | -5.4 | -3.2 | 3.5 |
| Brahman | 40 | 880 | 216 | 522 | 16.1 | 7.4 | 4.8 | 3.0 | 522 | 31.6 | 533 | 23.0 | 19.1 | 24.6 |
| Simmental | 47 | 983 | 239 | 510 | 33.6 | 5.6 | 20.0 | 8.3 | 514 | 24.4 | 519 | 9.1 | 2.7 | 10.0 |
| Limousin | 40 | 952 | 238 | 475 | 33.8 | 17.7 | 16.7 | 15.4 | 483 | -7.3 | 495 | -14.9 | -11.1 | -15.9 |
| Charolais | 68 | 894 | 235 | 499 | 18.2 | 5.7 | 5.5 | 2.5 | 501 | 11.3 | 512 | 2.1 | -4.6 | 2.6 |
| Maine-Anjou | 17 | 485 | 86 | 533 | 15.9 | 3.5 | 22.9 | 4.7 | 509 | 19.1 | 504 | -6.7 | -1.8 | 7.6 |
| Gelbvieh | 46 | 843 | 231 | 526 | 36.4 | 17.3 | 30.9 | 17.3 | 513 | 23.3 | 517 | 6.3 | 6.1 | 1.7 |
| Pinzgauer | 15 | 545 | 133 | 504 | 0.6 | -1.0 | -1.7 | 6.4 | 502 | 12.4 | 495 | -14.9 | -7.7 | 6.1 |
| Tarentaise | 6 | 341 | 78 | 513 | 12.0 | 1.5 | -6.0 | 4.7 | 509 | 19.2 | 516 | 5.8 | 6.4 | 17.8 |
| Salers | 25 | 351 | 87 | 534 | 12.0 | 8.0 | 3.5 | 12.0 | 514 | 23.7 | 514 | 3.9 | 4.1 | 9.0 |
| Red Angus | 21 | 186 | 88 | 465 | 28.0 | 14.0 | 27.3 | 14.3 | 495 | 5.2 | 495 | -14.9 | -6.6 | -7.8 |
| Braunvieh | 7 | 502 | 92 | 542 | 6.6 | -0.4 | 7.7 | -0.8 | 516 | 26.1 | 516 | 5.6 | 8.9 | 22.2 |

Calculations:
(6) = (7) + (1, Angus)
(8) = (6) + $b_{WWT}$ [(2) - (4)] + $b_{MLK}$ [(3) - (5)] with $b_{WWT}$ = 0.59 and $b_{MLK}$ = 1.13
(9) = (8) - (8, Angus)
(10) = [(9) - Average (9)] - 0.5[(7, Table 2) - Average (7, Table 2)]
(11) = [(10) - (10, Angus)] - [(3) - (3, Angus)]

**Table 5.** Mean weighted[a] accuracies for birth weight (BWT), weaning weight (WWT), yearling weight (YWT), maternal weaning weight (MWWT) and milk (MILK) for bulls used at MARC

| Breed | BWT | WWT | YWT | MWWT | MILK |
|---|---|---|---|---|---|
| Hereford | 0.56 | 0.53 | 0.48 | 0.49 | 0.47 |
| Angus | 0.87 | 0.87 | 0.84 | 0.83 | 0.82 |
| Shorthorn | 0.82 | 0.80 | 0.74 | 0.81 | 0.78 |
| South Devon | 0.37 | 0.39 | 0.37 | 0.41 | 0.42 |
| Brahman | 0.50 | 0.54 | 0.37 | 0.55 | 0.42 |
| Simmental | 0.94 | 0.93 | 0.93 | 0.95 | 0.94 |
| Limousin | 0.92 | 0.88 | 0.82 | 0.90 | 0.85 |
| Charolais | 0.71 | 0.65 | 0.56 | 0.63 | 0.54 |
| Maine-Anjou | 0.72 | 0.71 | 0.71 | 0.71 | 0.71 |
| Gelbvieh | 0.72 | 0.65 | 0.52 | 0.68 | 0.56 |
| Pinzgauer | 0.85 | 0.68 | 0.62 | 0.70 | 0.64 |
| Tarentaise | 0.95 | 0.95 | 0.94 | 0.95 | 0.95 |
| Salers | 0.83 | 0.82 | 0.77 | 0.82 | 0.83 |
| Red Angus | 0.87 | 0.84 | 0.84 | 0.84 | 0.80 |
| Braunvieh | 0.84 | 0.85 | 0.83 | 0.85 | 0.77 |
| Brangus | 0.76 | 0.75 | 0.61 | – | – |
| Beefmaster | 0.63 | 0.72 | 0.57 | – | – |

[a]Weighted by number of progeny at MARC for BWT, WWT, and YWT and by number of grandprogeny for MWWT and MILK.

**Table 6.** REML estimates of variance components ($lb^2$) for birth weight (BWT), weaning weight (WWT), yearling weight (YWT), and maternal weaning weight (MWWT) from mixed model analyses

| | Direct | | | Maternal |
|---|---|---|---|---|
| Analysis [a] | BWT | WWT | YWT | MWWT |
| Direct | | | | |
| Sires (650) within breed (17) | 11.4 | 152 | 631 | |
| Dams (4395) within breed (3) | 26.6 | 876 | 1233 | |
| Residual | 68.2 | 1535 | 4037 | |
| Maternal | | | | |
| MGS (573) within MGS breed (15) | | | | 192 |
| Daughters within MGS (3017) | | | | 916 |
| Residual | | | | 1303 |

[a]Numbers for weaning weight.

**Table 7.** Pooled regression coefficients (lb/lb) for weights at birth (BWT), 205 days (WWT), and 365 days (YWT) of $F_1$ progeny on sire expected progeny difference and by sire breed, dam breed, and sex of calf

| | BWT | WWT | YWT |
|---|---|---|---|
| **Pooled** | 1.05 ± 0.05 | 0.86 ± 0.05 | 1.13 ± 0.05 |
| **Sire breed** | | | |
| Hereford | 1.16 ± 0.08 | 0.78 ± 0.07 | 1.12 ± 0.07 |
| Angus | 1.02 ± 0.11 | 0.80 ± 0.10 | 1.16 ± 0.08 |
| Shorthorn | 0.64 ± 0.48 | 0.75 ± 0.42 | 1.15 ± 0.34 |
| South Devon | 0.92 ± 0.58 | -0.18 ± 0.37 | -0.06 ± 0.41 |
| Brahman | 1.82 ± 0.27 | 1.11 ± 0.27 | 0.69 ± 0.24 |
| Simmental | 1.05 ± 0.22 | 1.23 ± 0.17 | 1.27 ± 0.15 |
| Limousin | 0.68 ± 0.17 | 0.55 ± 0.16 | 1.16 ± 0.15 |
| Charolais | 1.01 ± 0.14 | 0.95 ± 0.14 | 0.92 ± 0.13 |
| Maine-Anjou | 1.08 ± 0.37 | 0.55 ± 0.49 | 0.15 ± 0.50 |
| Gelbvieh | 1.01 ± 0.16 | 1.27 ± 0.27 | 1.34 ± 0.22 |
| Pinzgauer | 1.26 ± 0.17 | 1.49 ± 0.21 | 1.66 ± 0.16 |
| Tarentaise | 0.67 ± 0.89 | 0.76 ± 0.55 | 1.38 ± 0.61 |
| Salers | 1.20 ± 0.39 | 0.98 ± 0.45 | 0.80 ± 0.45 |
| Red Angus | 0.55 ± 0.19 | 0.55 ± 0.34 | 0.77 ± 0.30 |
| Braunvieh | 0.46 ± 0.37 | 0.78 ± 0.76 | 1.97 ± 0.53 |
| Brangus | 1.25 ± 0.32 | 0.81 ± 0.46 | 0.39 ± 0.41 |
| Beefmaster | 1.61 ± 0.57 | 1.48 ± 0.38 | 1.60 ± 0.43 |
| **Dam breed** | | | |
| Hereford | 0.98 ± 0.08 | 0.79 ± 0.08 | 1.00 ± 0.07 |
| Angus | 1.12 ± 0.06 | 0.89 ± 0.07 | 1.17 ± 0.06 |
| MARC III | .99 ± 0.08 | 0.86 ± 0.09 | 1.20 ± 0.09 |
| **Sex of calf** | | | |
| Heifers | 1.03 ± 0.06 | 0.96 ± 0.06 | 0.93 ± 0.06 |
| Steers | 1.06 ± 0.06 | 0.76 ± 0.06 | 1.30 ±.0 06 |

**Table 8.** Pooled regression coefficients (lb/lb) for progeny performance on maternal grandsire EPD for weaning weight (MWWT) and milk (MILK) and by breed of maternal grandsire, breed of maternal grandam, and sex of calf

| Type of regression | MWWT | MILK |
|---|---|---|
| **Pooled** | 0.59 ± 0.04 | 1.13 ± 0.06 |
| **Breed of maternal grandsire** | | |
| Hereford | 0.57 ± 0.06 | 1.14 ± 0.11 |
| Angus | 0.60 ± 0.09 | 1.07 ± 0.13 |
| Shorthorn | 0.30 ± 0.36 | 0.83 ± 0.49 |
| South Devon | 0.31 ± 0.25 | -1.16 ± 0.82 |
| Brahman | 0.44 ± 0.21 | 0.54 ± 0.33 |
| Simmental | 0.73 ± 0.18 | 1.08 ± 0.44 |
| Limousin | 1.12 ± 0.14 | 2.00 ± 0.26 |
| Charolais | 0.44 ± 0.12 | 1.39 ± 0.22 |
| Maine-Anjou | 0.13 ± 0.34 | 0.47 ± 0.38 |
| Gelbvieh | 0.96 ± 0.25 | 1.56 ± 0.33 |
| Pinzgauer | 0.71 ± 0.19 | 0.28 ± 0.58 |
| Tarentaise | 0.20 ± 0.67 | 0.76 ± 0.81 |
| Salers | 0.89 ± 0.32 | 2.24 ± 0.35 |
| Red Angus | 0.71 ± 0.36 | 1.34 ± 0.39 |
| Braunvieh | 0.00 ± – | 2.83 ± – |
| **Breed of maternal grandam** | | |
| Hereford | 0.57 ± 0.06 | 1.51 ± 0.10 |
| Angus | 0.63 ± 0.05 | 1.18 ± 0.09 |
| MARC III | 0.52 ± 0.08 | 0.80 ± 0.12 |
| **Sex of calf** | | |
| Heifers | 0.60 ± 0.05 | 1.13 ± 0.08 |
| Steers | 0.58 ± 0.05 | 1.12 ± 0.08 |

**Table 9.** Variances ($lb^2$) of adjusted breed differences to add to sum of within breed prediction error variances to obtain variance of differences of across breed EPDs for bulls of two different breeds[a]. Birth weight above diagonal and yearling weight below the diagonal.

| Breed | HE | AN | SH | SD | BR | SI | LI | CH | MA | GE | PI | TA | SA | RA | BV | BS | BM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HE | 0.0 | 0.2 | 0.8 | 1.4 | 0.5 | 0.5 | 0.5 | 0.4 | 1.0 | 0.4 | 0.8 | 2.6 | 0.8 | 0.8 | 1.2 | 0.9 | 1.0 |
| AN | 14 | 0.0 | 0.9 | 1.4 | 0.5 | 0.5 | 0.5 | 0.4 | 1.1 | 0.5 | 0.9 | 2.6 | 0.8 | 0.8 | 1.2 | 0.9 | 1.0 |
| SH | 53 | 54 | 0.0 | 2.0 | 1.2 | 1.1 | 1.2 | 1.0 | 1.6 | 1.0 | 1.3 | 3.1 | 1.1 | 1.4 | 1.7 | 1.7 | 1.7 |
| SD | 83 | 83 | 122 | 0.0 | 1.7 | 1.3 | 1.4 | 1.3 | 2.1 | 1.6 | 2.0 | 3.7 | 1.9 | 1.8 | 2.3 | 2.2 | 2.3 |
| BR | 36 | 37 | 78 | 110 | 0.0 | 0.9 | 0.9 | 0.8 | 1.3 | 0.8 | 0.9 | 2.6 | 1.1 | 1.2 | 1.5 | 1.3 | 1.4 |
| SI | 28 | 29 | 69 | 80 | 56 | 0.0 | 0.5 | 0.5 | 1.3 | 0.6 | 1.1 | 2.8 | 1.1 | 0.8 | 1.4 | 1.3 | 1.3 |
| LI | 31 | 31 | 72 | 83 | 58 | 30 | 0.0 | 0.5 | 1.3 | 0.7 | 1.1 | 2.9 | 1.1 | 0.9 | 1.5 | 1.3 | 1.4 |
| CJ | 24 | 25 | 61 | 81 | 52 | 29 | 31 | 0.0 | 1.2 | 0.5 | 1.0 | 2.7 | 0.9 | 0.8 | 1.3 | 1.2 | 1.3 |
| MA | 62 | 64 | 97 | 128 | 86 | 75 | 78 | 72 | 0.0 | 1.0 | 1.5 | 3.2 | 1.5 | 1.6 | 1.1 | 1.9 | 1.9 |
| GE | 28 | 29 | 64 | 95 | 54 | 38 | 39 | 34 | 62 | 0.0 | 1.0 | 2.8 | 0.9 | 0.8 | 1.2 | 1.2 | 1.3 |
| PI | 53 | 55 | 85 | 123 | 65 | 69 | 72 | 64 | 94 | 64 | 0.0 | 2.6 | 1.3 | 1.4 | 1.6 | 1.7 | 1.7 |
| TA | 151 | 154 | 188 | 220 | 158 | 167 | 170 | 163 | 191 | 164 | 156 | 0.0 | 3.1 | 3.2 | 3.4 | 3.4 | 3.5 |
| SA | 49 | 50 | 70 | 118 | 74 | 66 | 68 | 57 | 93 | 60 | 83 | 184 | 0.0 | 1.4 | 1.7 | 1.6 | 1.7 |
| RA | 46 | 46 | 88 | 111 | 75 | 49 | 51 | 48 | 95 | 52 | 89 | 188 | 84 | 0.0 | 1.7 | 1.5 | 1.6 |
| BV | 69 | 71 | 105 | 135 | 93 | 83 | 85 | 79 | 68 | 69 | 102 | 198 | 101 | 102 | 0.0 | 2.0 | 2.1 |
| BS | 66 | 65 | 114 | 142 | 97 | 86 | 88 | 83 | 123 | 86 | 114 | 213 | 110 | 100 | 130 | 0.0 | 1.0 |
| BM | 66 | 66 | 115 | 142 | 97 | 86 | 89 | 83 | 123 | 87 | 115 | 213 | 111 | 102 | 131 | 78 | 0.0 |

[a]For example, a Hereford bull has within breed PEV of 300 for YWT and that for a Shorthorn bull is 200. Then the PEV for the difference in EPDs for the two bulls is 53 + 300 + 200 = 553 with SEP $= \sqrt{553}$ = 23.5.

**Table 10.** Variances ($lb^2$) of adjusted breed differences to add to sum of within breed prediction error variances to obtain variance of difference of across breed EPDs for bulls of two different breeds. Weaning weight direct above diagonal and MILK below the diagonal.

| Breed | HE | AN | SH | SD | BR | SI | LI | CH | MA | GE | PI | TA | SA | RA | BV | BS | BM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HE | 0 | 4 | 19 | 28 | 11 | 9 | 10 | 8 | 22 | 9 | 15 | 42 | 18 | 17 | 24 | 20 | 20 |
| AN | 14 | 0 | 20 | 28 | 11 | 10 | 10 | 8 | 23 | 9 | 16 | 43 | 18 | 17 | 25 | 20 | 20 |
| SH | 50 | 52 | 0 | 43 | 27 | 25 | 26 | 22 | 36 | 23 | 29 | 56 | 26 | 33 | 38 | 38 | 38 |
| SD | 58 | 59 | 97 | 0 | 36 | 27 | 28 | 27 | 45 | 32 | 40 | 66 | 42 | 39 | 47 | 46 | 46 |
| BR | 25 | 27 | 65 | 74 | 0 | 18 | 18 | 16 | 29 | 17 | 18 | 43 | 25 | 26 | 31 | 29 | 29 |
| SI | 26 | 27 | 65 | 60 | 42 | 0 | 10 | 9 | 27 | 12 | 21 | 48 | 24 | 18 | 29 | 27 | 27 |
| LI | 28 | 29 | 67 | 62 | 44 | 31 | 0 | 10 | 28 | 13 | 22 | 48 | 25 | 18 | 29 | 28 | 28 |
| CJ | 21 | 23 | 58 | 59 | 37 | 28 | 30 | 0 | 26 | 11 | 19 | 46 | 21 | 18 | 27 | 26 | 26 |
| MA | 54 | 57 | 91 | 100 | 69 | 68 | 70 | 63 | 0 | 22 | 31 | 58 | 35 | 35 | 24 | 41 | 41 |
| GE | 23 | 25 | 59 | 68 | 39 | 34 | 36 | 29 | 58 | 0 | 19 | 46 | 21 | 19 | 23 | 27 | 27 |
| PI | 50 | 53 | 84 | 97 | 57 | 66 | 67 | 60 | 82 | 61 | 0 | 41 | 27 | 29 | 33 | 34 | 34 |
| TA | 122 | 125 | 160 | 169 | 126 | 138 | 140 | 133 | 153 | 122 | 133 | 0 | 55 | 56 | 59 | 61 | 60 |
| SA | 41 | 44 | 69 | 88 | 57 | 57 | 58 | 49 | 82 | 50 | 69 | 148 | 0 | 31 | 37 | 37 | 37 |
| RA | 47 | 48 | 86 | 89 | 64 | 53 | 54 | 50 | 95 | 60 | 90 | 146 | 84 | 0 | 37 | 34 | 34 |
| BV | 81 | 83 | 118 | 126 | 96 | 95 | 96 | 90 | 97 | 83 | 115 | 187 | 100 | 115 | 0 | 43 | 42 |
| BS | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 0 | 21 |
| BM | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 0 |