ACROSS-BREED EPD TABLES FOR THE YEAR 2002 ADJUSTED TO BREED DIFFERENCES FOR BIRTH YEAR OF 2000

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Introduction

This report is the year 2002 update of estimates of sire breed means from data of the Germplasm Evaluation (GPE) project at the U.S. Meat Animal Research Center (MARC) adjusted to a year 2000 base using EPDs from the most recent national cattle evaluations. Factors to adjust EPD of 15 breeds to a common birth year of 2000 were calculated and reported in Tables 1-4.

Changes from the 2001 update (Van Vleck and Cundiff, 2001) are as follows:

1) Braunvieh data were added for the first time with 132 calves and 5 sires used in Cycle I of GPE. Weaning weights of 328 grandprogeny of 60 daughters were used in the maternal analysis.
2) Maternal data were available for the first time on 34 grandprogeny of 34 daughters of 15 Red Angus sires.
3) No EPDs were reported this year for 7 Hereford sires used in Cycles I and II of GPE, resulting in deletion of weaning weight records of 296 of their progeny and 532 grandprogeny by 117 daughters. A more recent sample of Hereford bulls (1 born in 1983, and 8 born in 2000) added 63 progeny with weaning weights.
4) The most recent sample of Angus bulls (9 born in 2000) added 59 progeny with weaning weights.
5) New sires of Angus (13), Hereford (13), Simmental (15), Limousin (14), Charolais (15), and Gelbvieh (15) breeds had grandprogeny with weaning weights for the maternal analysis for the first time.

The across-breed table adjustments apply **only** to EPD for most recent (in most cases; spring, 2002) national cattle evaluations. Serious biases can occur if the table adjustments are used with earlier EPD which may have been calculated with a different within-breed base.

Materials and Methods

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 direct and maternal heterozygosity for MILK analysis and 100% of direct heterozygosity for 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, Brahman, 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 were tried which resulted in similar final table adjustments. One approach is to include level of heterozygosity in the statistical models which essentially adjusts to a basis of no heterozygosity. The other approach is 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.

The steps were:

1) Analyze records from H-A diallel experiments to estimate direct heterosis effects for BWT, WWT, YWT (1,140, 1,073, and 1,049 records for BWT, WWT, and YWT, respectively, representing 145 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 (1999-2000) 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 2,465 weaning weight records of 602 daughters representing 151 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 3.30, 15.40, and 31.70 lb for BWT, WWT and YWT, respectively. The estimate of maternal heterosis was 25.76 lb for MWWT. As an example of step 3), birth weight of a H by H calf would have 3.30 added. A Red Angus by MARC III calf would have (1/4) (3.30) added to its birth weight. A Red Poll sired calf of an Angus by MARC III cow would have (1/8) (15.40) plus (1/4) (25.76) 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, 1998, 1999, 2000, 2001). 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 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 (15), 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 (20) of birth (1970-76, 86-90, 92-94 and 97-99, 2000-01) by damline combination (99) 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 have been used in 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 (4291 dams for BWT, 4049 for WWT, 3933 for YWT). For estimation of variance components and to estimate breed of sire effects, sire of calf was also used as a random effect (591).

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 variance 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 analyses of maternal effects included breed of maternal grandsire (15), maternal grand dam line (Hereford, Angus, MARC III), breed of natural service mating sire (16), sex of calf (2), birth year-GPE cycle-age of dam subclass (71), and mating sire breed by GPE cycle by age of dam subclass (38) 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 dams 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 (509) and dam (2,455 daughters of the maternal grandsires). 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 included in calculation of within-breed EPD.
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).

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

Breed table factor 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,

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 = 2000 for 2002 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 2002: 1.01, 0.90, and 1.19 for BWT, WWT, YWT),

i denotes breed i, and

x denotes the base breed x, 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 2002: 0.51 and 1.18),

$M(i) = M_i$ 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 2000 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 2000. These pairs of differences minus the corresponding differences in average EPD for animals born in 2000 result in the last column of the tables to be used as adjustments for pairs of within-breed EPD.

Birth Weight

The range in estimated breed of sire difference for BWT relative to Angus are large and range from 1.2 lb for Red Angus to 9.3 lb for Charolais and 12.1 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. In general, the changes from the 2001 update were slightly smaller differences from Angus with most changes of less than a pound. Changes in differences between other breeds were smaller. The smaller differences from Angus may be due to Angus calves becoming bigger or other calves becoming smaller at birth. In any case, the breeds seem to be becoming more similar, although still quite different for BWT.

Suppose the EPD for birth weight for a Charolais bull is +2.0 (which is above the year 2000 average of 1.6 for Charolais), and for a Hereford bull is also +2.0 (which is below the year 2000 average of 3.9 for Herefords). Then the adjusted EPD for the Charolais bull is 10.3 + 2.0 = 12.3 and for the Hereford bull is 3.0 + 2.0 = 5.0. The expected birth weight difference when both are mated to another breed of cow, e.g., Angus would be 12.3 - 5.0 = 7.3 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 2001 and 2002 updates were about 2 lb or less. Most sire breed means for WWT adjusted to year of birth of 2000 are within 10 lb of the Angus mean. The only large change from Angus from the update for 2001 to the 2002 update was a decrease of nearly 9 lb for Herefords.

Yearling Weight

The only large change from the year 2001 update was a decrease of 19 lb for Herefords compared to Angus for the base year of 2000. Nine breeds decreased in yearling weight relative to Angus but by relatively small amounts since the year 2001 update. The three breeds that increased relative to Angus did so by 1.5 to 3.7 lb. Adjusted to a base year of 2000, Angus have heavier yearling weights than 10 breeds (1.1 to 45.7 lb) and lighter yearling weights than 3 breeds (0.2 to 17.0 lb).

MILK

Maternal milk adjusted to a 2000 year of birth was second highest for Braunvieh (based on limited numbers of daughters of Braunvieh sires). The Red Angus had, for the first time, a milk evaluation which, with few Red Angus daughters, was similar to that for Angus. Nine breeds decreased relative to Angus (1.8 to 5.8 lb) and three increased (0.3 to 3.1 lb) since the year 2001 update. The largest decreases were for Simmental (5.8 lb) and Gelbvieh (5.8 lb). Herefords also declined relative to Angus by 3.6 lb, which follows the pattern for all traits.

The largest changes between the year 2001 and year 2002 updates were for the differences in WWT and YWT between Hereford and Angus. The new records were from 57 progeny of 8 Hereford sires with moderate accuracy (range of 0.53 to 0.83) and from 59 progeny of 9 Angus sires with high accuracy (0.87 to 0.99; six with 0.99). Failure to report EPD of seven old Hereford sires resulted in loss of 288 progeny of five of these, all of which had low accuracy (0.12 to 0.43) and a limited range of current EPD (for WWT; 0 to 11 lb). Thus, the changes in Hereford vs Angus may reflect recent trends in Angus and Herefords or sampling variation in the early and/or late Herefords. In fact, calculations ignoring the Cycle 8 Angus and Hereford matings show that most of the change in difference between Hereford and Angus from the year 2001 to the year 2002 updates was due to the failure to report the EPD for the seven older low accuracy Hereford sires which excluded progeny of those sires from the year 2002 update. The regressions of progeny performance at MARC on breed association EPD have regularly been similar for Herefords and Angus. The changes for Hereford relative to Angus are generally in the same direction as for other breeds relative to Angus except somewhat larger. What is apparent is that the breeds are changing.

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. 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 2001 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 1.01 for BWT, 0.90 for WWT, and 1.19 for YWT were used to estimate breed solutions as of the 2000 birth year. 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 15 breeds.
The regressions by sex for YWT EPD changed in 1998 so that the female regression (1.13) was smaller than the male regression (1.23) whereas in 1997 the reverse was found (1.29 and 1.19). For YWT in 1999, the female regression decreased to 1.02 and the male regression increased to 1.32 which are similar to the 1.02 and 1.36 in the year 2002 analysis. This pattern of the regression coefficients by sex changing over years has not yet been explained. The change in 1998 was thought to be due to joint adjustment of records for sex, age of dam and dam breed.

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 overall all breeds of grandsires associated with heifers and steers overlap for milk EPD. Again, the pooled regression coefficients of 0.51 for MWWT and 1.18 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):

$$(26.1 + 15.0) - (-6.9 + 30.0) = 41.1 – 23.1 = 18.0.$$

The prediction error variance for this difference is (use the 19.0 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):

$$19 + 75 + 50 = 144$$

with

standard error of prediction $\sqrt{144} = 12$.

If the difference between the Salers and Hereford breeds in the year 2000 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 15 breeds. The AB-EPDs are most useful to commercial producers purchasing bulls of two or more breeds to use in systematic crossbreeding programs. Uniformity in AB-EPDs should be emphasized for rotational crossing. Divergence in AB-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 AB-EPDs depend primarily upon the accuracy of the within-breed EPDs of individual bulls being compared.

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