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Prediction of Progeny Genetic Evaluations from Simultaneous Genetic Evaluations of the Dam, Sire, and Maternal Grandsire with an Animal Model

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Prediction of Progeny Genetic Evaluations from Simultaneous Genetic Evaluations of the Dam, Sire, and Maternal Grandsire with an Animal Model

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ABSTRACT

Simultaneous genetic evaluations for bulls and cows obtained by mixed model procedures with an animal model incorporating all numerator relationships for artificially sired Holstein cows in northeastern United States were compared with separate (Northeast) mixed model evaluations of cows and sires for predicting genetic evaluations of progeny from dam, sire, and maternal grandsire evaluations. Regression coefficients for progeny (322,104 daughters and 837 sons) evaluations on dam, sire, and maternal grandsire evaluations were for daughters: Northeast evaluations; .50, .37, and −.02 compared to theoretical coefficients of .74, .52, and −.13, and simultaneous evaluations; .61, .50, and −.09 compared to theoretical coefficients of .73, .52, and −.12. For sons, comparable regression coefficients were: Northeast evaluations; .08, .42, and .06 compared to theoretical coefficients of .33, .59, and .00 and simultaneous evaluations; .92, .46 and −.29 compared to theoretical coefficients of 1.11, .54, and −.31. Efficiencies of evaluation procedures expressed as ratios of actual to theoretical multiple correlation coefficients were for daughters: Northeast evaluations, .70/.93 = .75; and simultaneous evaluations, .88/.93 = .95; and were for sons: Northeast evaluations, .50/.64 = .78; and simultaneous evaluations, .85/.89 = .95. Northeast evaluations were 79 and 82% as efficient as simultaneous evaluations for daughters and sons, respectively.

INTRODUCTION

Artificial insemination organizations and dairy farmers depend on genetic evaluations to select dams of sons to sample and dams to produce heifer replacements. Many reports have suggested that dam information does not predict son or daughter genetic value as well as theoretically possible (2, 4, 5, 6, 9, 10, 12, 17, 18). Evaluations for dams that include other than first lactation records have produced regressions for offspring on dams that are much smaller than genetic theory predicts. Regression coefficients associated with mixed model evaluations utilizing relationships are somewhat difficult to compare with theoretical regression coefficients because information used to evaluate one relative is also used to evaluate other relatives (11, 18). Westell and Van Vleck (17, 18) summarized studies using Northeast AI sire comparisons (NEAISC) and intraherd cow evaluations (1, 7) in the Northeast (NE ETA). Similar studies have been done with USDA evaluations (2, 3, 4, 5, 9, 10, 12).

Simultaneous evaluation of cows and bulls with an animal model (15, 19) incorporates as many relationships as possible into the evaluations and features the same grouping structure to account for genetic selection trend for both bulls and cows (6, 8, 14, 15). The purpose of this study was to determine whether simultaneous evaluations are better predictors of sons and daughters than separate mixed model evaluations for bulls and cows.

MATERIALS AND METHODS

Data were simultaneous genetic evaluations using an animal model with complete relation-

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TABLE 1. Regression coefficients for regression of heifer (H) evaluation on dam's (D), sire's (S), and maternal grandsire's (M) evaluations.

Evaluation and regression[1]	Regression coefficients			
	D	S	M	R^2
Northeast				
Within herd[3]	.50	.37	−.02	.70
Across herds[3]	.51	.36	−.03	.72
Theoretical	.74	.52	−.13	.93
Simultaneous				
Within herd[3]	.61	.50	−.09	.88
Across herds[3]	.60	.50	−.09	.89
Theoretical	.73	.52	−.12	.93

[1]Correlations between Northeast and simultaneous evaluations of H are .71 within herd, and .72 across herds.

[2]Multiple correlation coefficient.

[3]Degrees of freedom: 317,399 for within-herd and 322,100 for across-herd analyses. Standard errors of the regression coefficients are approximately .002.

lactation milk records of 1,074,971 daughters of 6000 bulls (13, 16, 19). The NEAISC and NE ETA evaluations using only first lactation records were matched to the simultaneous evaluations. A file was created for bulls that had an evaluation with corresponding evaluations for their sire, their dam, and their maternal grandsire. Only 837 bulls with evaluations had dams, sires, and maternal grandsires with evaluations. A similar file was created for heifers. A total of 322,104 cows with evaluations had dams, sires, and maternal grandsires with evaluations.

Let B, the bull's evaluation, and H, the heifer's evaluation, be the dependent variables and D, S, and M (the dam's, sire's, and maternal grandsire's evaluations) be the predictor variables for multiple regression.

Then B or H was regressed on D, S, and M using either the simultaneous evaluations or the Northeast single-trait evaluations. Records for the Northeast evaluation procedure were not transformed to logarithms. The regressions were within year of birth of heifers or within one of four groups based on registration number of bulls to determine any trends over time and overall.

Regressions for H were done two ways: within herd or ignoring herd of the heifers. Theoretical approximations to the regression coefficients were computed assuming one record on a cow and 50 daughters for each bull and sire and maternal grandsire following (11, 18).

RESULTS AND DISCUSSION

Prediction of Heifer Evaluations

Table 1 lists the regression analyses for heifers. Results of the across-herd and within-herd analyses are nearly the same. The theoretical approximations to the regression coefficients are essentially the same for the Northeast and simultaneous procedures because the approximations assumed the daughter (heifer) and dam were in the same herd. The reason for the negative regression on M is that information from progeny of the maternal grandsire is included in D for both Northeast ETA and simultaneous evaluations. The regression coefficients for the simultaneous evaluations more nearly match the theoretical approximations than do the regression coefficients for the Northeast D, S, and M.

Genetic progress is proportional to the correlation between actual and predicted genetic value. Although the predictor variable in this analysis is predicted genetic value rather than genetic value, the ratio of the actual to the theoretically approximated multiple correlation coefficient (R) might be an appropriate measure of efficiency of the evaluation procedures. Efficiency for the Northeast evaluations is about 76% and for the simultaneous evaluations is about 95% for predicting the genetic evaluation of a cow from the D, S, and M.

The trends in the regression coefficients over time are not shown, but both the Northeast and

TABLE 2. Regression coefficients for regression of 837 bull (B) evaluations on dams' (D), sires' (S), and maternal grandsire's (M) evaluations.

	Regression coefficients			
Evaluation[1]	D	S	M	R^2
Northeast				
Actual	.08	.42	.06	.50
Theoretical	.33	.59	.00	.64
Simultaneous				
Actual	.92	.46	−.29	.85
Theoretical	1.11	.54	−.31	.89

[1]Correlation between Northeast and simultaneous evaluations is .93.

[2]Multiple correlation coefficient.

simultaneous evaluations show a disturbing trend. For Northeast evaluations, the regression coefficient for D decreases slowly from about .57 for H of cows born in the early 1960s to about .45 for H of cows born in 1978 through 1980. For simultaneous evaluations, the pattern is similar except the regression coefficients are larger: .75 in the early 1960s to .56 in 1978 through 1980.

Trends in the regression coefficients on S over time are different for Northeast and simultaneous evaluations. The regression on S for the Northeast evaluations increased from about .23 in 1961 through 1963 to .43 in 1978 through 1980, whereas for the simultaneous evaluations, the regression coefficient varied only slightly, between .50 and .51 from 1961 through 1980.

The multiple correlation coefficients for Northeast evaluations increased slightly over time from about .60 to .66 for the within-herd analysis but were very stable (.65 to .68) for the across-herd analysis. The simultaneous evaluations showed the opposite trend; R decreased from about .89 to .81 for the within-herd analyses and from about .91 to .83 for the across-herd analyses for the period 1961 through 1980.

The means for S and D behaved as expected for the simultaneous evaluations. Mean for H was for all years of birth nearly the same as the average of means for corresponding S and D. For the Northeast evaluations, the averages of means for S and D were not close to the average of H, especially for cows born from 1960 to 1972 when the mean for S was markedly less than for H and D, which were similar. This difference in the evaluation procedures probably indicates the grouping procedure used in the simultaneous evaluation more properly accounts for genetic trend in both the cow and bull populations than ignoring grouping in cow evaluations, except for the inclusion of separately computed bull evaluations that do include grouping.

Correlations among the evaluations provide some indication of assortative mating. The correlations between D and S were .08 for the Northeast evaluations and .09 for the simultaneous evaluations on a within-herd basis and .12 and .16 when herds were ignored. The theoretical approximation to the correlation with random mating is about .02. The within-herd correlations between S and M were .14 for Northeast evaluations and .11 for simultaneous evaluations and the correlations when herds were ignored were .24 and .20 compared with a theoretical correlation of .01.

The correlations within herds for H with D, S, and M from Northeast procedures were .50, .52, and .26 compared with theoretical approximations of .60, .71, and .36. The corresponding correlations from simultaneous evaluations were .55, .73, and .37 compared with theoretical correlations of .60, .71, and .38.

Prediction of Bull Evaluations

Table 2 contains the regression analyses for bulls. The results are similar to those for cows. The regression coefficients for simultaneous evaluation much more closely agree with their

theoretical approximations than do the Northeast evaluations with their theoretical approximations, especially for the dam of the bull. The reason for the differences in the D and M regression coefficients between Northeast and simultaneous evaluations is that the dam's record is not included in her son's evaluation for the Northeast evaluation but is included with the simultaneous evaluation. Efficiencies of evaluation based on ratios of actual to theoretical multiple correlation coefficients are 78% for Northeast evaluations and 95% for simultaneous evaluations.

When bulls were divided into four groups based on registration number, the results for each group were much the same as for the overall analyses with any fluctuations probably due to sample size.

The correlations among the evaluations used to predict B show a positive correlation between D and S (.34 for Northeast and .22 for simultaneous evaluations) and between S and M (.37 for Northeast and .32 for simultaneous evaluations) as compared with theoretical correlations of nearly zero with random mating. The correlations are evidence of positive assortative mating for obtaining sons for artificial insemination.

CONCLUSIONS

The theoretical advantages of simultaneous evaluations of bulls and cows from using all relatives and the same grouping procedure for both bulls and cows seem to result in evaluations of progeny (bulls or heifers) that agree more with theory than do separate mixed model evaluations for bulls and cows. Efficiency of selection based on the ratios of actual and approximated theoretical multiple correlation coefficients for predicting an offspring's evaluation from D, S, and M may be about 19% greater for cows and 17% greater for bulls by using simultaneous evaluations as compared to separate bull and cow evaluations. The ability of D to predict either daughter or son evaluations much more nearly matches theoretical expectations for simultaneous evaluations than for separate evaluations. Nevertheless, in neither system do the actual regression coefficients match theoretical regression coefficients as well as would be desirable. Reasons for any differences from a theoretically optimum set of regression coefficients need to be determined. Nevertheless, simultaneous evaluation seems to have practically important advantages for increasing genetic improvement as compared to separate evaluations. An educational advantage is the ease with which the animal model evaluation can be explained as compared with separate evaluations.

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