SELECTION FOR TWINNING IN CATTLE

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SUMMARY

Estimates of genetic parameters for a two-trait twinning and ovulation rate model with genetic groups were: heritabilities of .03 for twinning and .07 for ovulation with a genetic correlation of nearly 1.00 and fractional permanent environmental variances of .06 for twinning and .05 for ovulation rate. Corresponding estimates when group effects were ignored were: heritabilities of .08 and .08 and fractional permanent environmental variances of .02 and .04 for twinning and ovulation, respectively. Twinning rate (%) in the project at the US Meat Animal Research Center has increased in all cows born in the project by year of calving from 3.4% in 1982 to 28.5% in 1993, a phenotypic increase of 25.1%. The estimated genetic change in twinning of cows by year of calving using the groups model has been 15.2%. The increase in average genetic value by year of birth has been 18.2% in twinning and 15.0% in ovulation rate from 1980 through 1991. Effects for seven selected groups of foundation animals ranged from -6.0% to 33.1% and influenced genetic trend.

INTRODUCTION

A selection project was started in 1981 at the US Meat Animal Research Center (MARC) to increase economic efficiency of beef production by increasing twinning frequency. Earlier papers from the project have described the foundation animals, effects of twinning on other traits, potential of ovulation rate as a selection guide, and estimates of heritabilities of, and, genetic correlation between, twinning and ovulation rate and the development of a multiple trait animal model for predicting breeding values as a tool for selection (Gregory et al., 1990a, 1990b: Echternkamp et al., 1990; Van Vleck et al., 1991a, 1991b). The objectives of this study were to re-estimate genetic parameters with a much larger set of records using the model implemented for predicting breeding values and to estimate genetic improvement due to selection.

MATERIALS AND METHODS

Parameters initially used in the multiple trait mixed model for prediction of breeding values for twinning and ovulation rate were from an amalgam of variance analyses of relatively limited data. The parameters were then applied to a model that contained groups to account for selection of seven groups of foundation animals. The groups model was used to combine twinning and ovulation records for prediction of breeding values in 1990. This model was used in this study to re-estimate the parameters. The two trait model included year-season of calving by age of dam subclass effects (12 x 2 x 4 = 96) for twinning rate and year-season of birth (8 x 2 = 16), coded age in months at measurement (< 11 to 18 months, 5 classes) and calendar month (12) effects for ovulation rate. Seven selection group effects were included as phantom parents of foundation animals (Quaas and Pollak, 1981; Westell et al., 1988). Random effects were animal genetic effects and animal permanent environmental effects which also account for genetic and environmental correlations between twinning and ovulation rate on the same cow. The remaining temporary environmental effects were assumed to be uncorrelated. A total of 3503 animals were included in calculation of the inverse of the numerator relationship matrix; 2087 animals had 6411 parturitions for measurement of twinning; and 2194 heifers had number of ovulations measured in 18,687 estrous cycles. The order of the mixed model equations was 13,365 when groups were included.

The MTDFREML program (Boldman et al., 1993) that uses a derivative-free algorithm was used to obtain (co)variance components by REML for models with and ignoring group effects. The program was restarted several times to assure global maximization of the likelihood. At convergence, solutions for predicted breeding values were obtained for twinning rate and ovulation rate and used to calculate genetic averages by year of calving and by year of birth.

RESULTS

Estimates of variance matrices, variances as proportions of total variance (h^2, c^2, e^2) and correlations are in Table 1. Temporary environmental variances were similar for the two models. The genetic variances were substantially less as might be expected for the model including group effects, particularly the genetic variance for twinning (h^2_t of .03 vs .08 and h^2_o of .07 vs .08). The genetic correlation, however, was larger with the group model (nearly 1.00 vs .76). With the groups model, the fraction of variance due to permanent environmental effects increased with the decrease in genetic variance (c^2_t of .06 vs .02 and c^2_o of .05 vs .04 with r_c = .53 vs .84). The earlier estimates used in genetic evaluations since 1990 (Van Vleck et al., 1991b) were (h^2_t = .07, h^2_o = .10, r_g = .89 and c^2_t = .001, c^2_o = .01, r_c = .19). The main differences between the new analysis and groups model as compared to what has been used for genetic evaluation are the reductions in genetic variance and increases in permanent environmental variance.

Table 1. Estimates of components of (co)variance and parameters for models with and without genetic groups: numbers of births per parity (t) and ovulations per estrous cycle (o) both multiplied by 100.

Component	Groups Yes	Groups No	Parameter	Groups Yes	Groups No
Genetic:					
$\sigma^2_{g_t}$	43.2	112.2	h^2_t	.03	.08
$\sigma_{g_t g_o}$	60.8	80.6	r_g	1.00	.76
$\sigma^2_{g_o}$	85.7	100.4	h^2_o	.07	.08
Permanent environment:					
$\sigma^2_{c_t}$	88.9	34.8	c^2_t	.06	.02
$\sigma_{c_t c_o}$	41.7	37.2	r_c	.53	.84
$\sigma^2_{c_o}$	68.9	56.4	c^2_o	.05	.04
Temporary environment:					
$\sigma^2_{e_t}$	1316.1	1321.6	e^2_t	.91	.90
$\sigma^2_{e_o}$	1108.9	1123.4	e^2_o	.88	.88

Trends as described by averages for year of calving and year of birth for cows born in the project are shown in Table 2. The unadjusted frequencies of number of births began at 103.4% (twinning rate would be 3.4%) for cows calving in 1982 or before and increasing to 128.5% for 1993 parturitions, an increase of 25.1%. The genetic mean for twinning increased by 15.2% or about 60% of the phenotypic change. Mean ovulation rate increased by 13.1%. When the model ignoring groups was used, the estimated genetic trend was less for both twinning and ovulation rates despite the larger heritabilities. The solutions for genetic groups shown in the footnote of Table 2 are involved in all predicted breeding values with the groups model. Some evidence suggests that part of the difference between the genetic and phenotypic trend is due to an increase in average permanent environmental effects because selection on phenotype leads to a temporary increase in average permanent environmental effects as well as an increase in average genetic effects. Another measure of genetic trend is that shown by changes in genetic averages by year of birth. The change in average predicted genetic value for twinning rate was 18.2% in 11 years and 15.0% for ovulation rate.

Table 2. For cows born in twinning project, mean twinning rate (%) and mean predicted genetic values for twinning and ovulation rates (%) by year of calving and year of birth estimated from the model including genetic groups[a] and estimates of parameters shown in Table 1.

Year calving	No. cows	Raw mean	Genetic Mean		Year born	No. cows	Genetic Mean	
			twinning	ovulation			twinning	ovulation
-	-	-	-	-	≤1980	42	0	0
-	-	-	-	-	81	26	-.7	-.8
≤1982	88	3.4	0	0	82	65	1.7	1.1
83	61	9.8	-1.0	-.8	83	120	3.7	2.4
84	109	5.5	-.4	-.5	84	171	4.3	3.1
85	215	6.5	1.5	.8	85	223	7.0	5.3
86	292	8.6	2.7	1.8	86	153	9.6	7.3
87	446	10.0	4.0	2.8	87	190	11.2	9.5
88	435	11.7	5.8	4.3	88	187	13.9	11.8
89	555	14.8	6.7	5.2	89	210	15.1	12.8
90	654	19.3	8.2	6.5	90	195	16.5	14.3
91	763	23.5	9.8	8.0	91	115	18.2	15.0
92	793	24.3	11.9	10.0	-	-	-	-
93	733	28.5	15.2	13.1	-	-	-	-

[a]Solutions for genetic groups 1 to 7 for twinning rate are: 26.5, 2.3, 10.8, 6.5, -6.0, 5.3, and 33.1.

DISCUSSION

The level of twinning achieved exceeds that reported (Frebling et al., 1982) in another experiment and levels found in unselected populations (e.g., Rutledge, 1975). Even with relatively low heritability on the observed scale, the rate of increase in average breeding value has accelerated. The change in ovulation rate is somewhat less, probably due to ovulation rate being measured at a young age on puberal heifers. Indirect selection based on ovulation rate averaged over about eight estrous cycles appears to be as effective in practice as in theory as heritability is larger and the genetic correlation with twinning seems to be near unity. Much of the success also seems due to fortuitous availability of semen from Swedish and Norwegian sires (group 1) and of two sires from another MARC project (group 7). Twinning rate has not changed in other contemporary populations at MARC that were not selected for twinning. Some of the difference between the phenotypic and genetic trends also may be due to more genetic variation in the underlying distribution than shown on the observed binomial scale.

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