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GENETIC PARAMETERS FOR GESTATIOB LENGTH, BIRTH DATE AND TIME TO FIRST OBSERVED ESTRUS IB BEEF CATTLE

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GENETIC PARAMETERS FOR GESTATION LENGTH, BIRTH DATE AND TIME TO FIRST OBSERVED ESTRUS IN BEEF CATTLE

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SUMMARY

Genetic and evironmental variability in gestation length (GL), birth date (BD), and time from first day of breeding season to first observed estrus (FE) were analyzed using twelve years of breeding and calving records on cows, sired by Simmental, Maine-Anjou, Limousin and Gelbvieh bulls. All cows were artificially inseminated. Statistical analyses were performed separately on first, second and last parity records. Paternal half-sib estimates of heritability for GL as a trait of the calf were between .36 and .45 while the estimates for BD were between .09 and .24. The estimates of heritability for FE, treated as a trait of the cow, were less than .10. Heritabilities for maternal additive effects were small for GL and BD. The correlation between direct and maternal additive effects were negative for GL and BD in parity 1 and for GL in parity 2. The expected annual responses to selection on an index that maximizes the sum of the direct and maternal breeding values were .76 d and 1.03 d for BD and GL, respectively.

INTRODUCTION

The net return for cow-calf producers is partially influenced by the calf-crop percentage or percent calves weaned per cow exposed to breeding services. A major determinant of this percentage is the reproductive efficiency of females. A suitable measure of reproductive efficiency, on which selection could be practiced, is yet to be found. Bourdon and Brinks (1983) compared calving date and calving interval as a measure of reproduction in beef cattle. They suggested that calving date would be more highly heritable and have a clearly identifiable economic value since earlier born calves would be heavier at a fixed weaning date.

The primary objective of this study was to determine the causes of genetic and non-genetic variation in three traits: gestation length (GL), birth date (BD), and time from first day of breeding season to first observed estrus (FE). The secondary objective was to estimate heritabilities for these traits and to determine the relative influence of direct and maternal additive variation, as well as the interaction of these sources of variation, on the traits studied. Possible annual response to selection for any of these traits was subsequently studied.

MATERIALS AND METHODS

Twelve years (1972 to 1983) of breeding and calving records on cows sired by Simmental, Maine-Anjou, Limousin and Gelbvieh bulls were studied in an single herd in the midwest U.S.A. Several other beef breeds were represented among the service sires used. All cows were artificially inseminated (AI) during fixed breeding seasons (spring or fall) each year. In some years, cows open after the AI period were exposed to natural service.

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Because of computational costs, all traits were analyzed separately for three different ages of cows thus giving rise to 9 separate analyses. One analysis was performed on first parity cows, another on second parity cows, and a third on the cows' last record given that the final record was not from her first or second parity. The number of records for parities 1, 2 and last were: 4,474, 2,803 and 2,504 for GL; 4,228, 2,688 and 2,429 for BD; and 4,242, 2,688 and 2,429 for FE. Gestation length and BD were both treated as traits of the calf while FE was treated as a trait of the dam. To avoid confusion, maternal grandsire designates the sire of the dam in all analyses, regardless whether the trait is that of the calf or of the dam.

The GL and BD data were described by a linear model including the effects of breed of maternal grandsire, maternal grandsire within breed of maternal grandsire, breed of service sire, service sire within breed of service sire, type of pregnancy (female fetus, male fetus or twins) and the breeding year-season combination. The effects were analyzed by least-squares methods using SAS (1982), GLM procedures. The FE data were described by a model including the effects of breed of maternal grandsire, maternal grandsire within breed of maternal grandsire, and breeding year-season combination.

Variance components were obtained by Henderson's Method 3 (Searle, 1971) using SAS VARCOMP procedures and the linear models above. Paternal half-sib heritabilities were estimated for direct additive effects, h^2_{Ao}. Heritabilities for GL and BD, as a trait of the dam, h^2_{MG}, were calculated as a comparison and was based on four times the maternal grandsire variance. All paternal effects were assumed to be negligible in estimation of the heritabilities and the genetic correlation. The pooled within-breed covariance between the least-squares means of sires with records both as service sires and as maternal grandsires (covariance between paternal half-sib mean and progeny mean of a female) was used in order to obtain estimates of the genetic covariance between direct and maternal additive effects, $r_{Ao,Am}$. An estimate of the additive maternal variance and thus of the heritability of additive maternal effects, h^2_{Am}, and the correlation between direct and maternal additive effects were obtained by using the estimates of the sire and maternal grandsire variances and the covariance between means of sires with records both as service sires and as maternal grandsires.

RESULTS

The non-genetic factors of year-season and calf type explained a significant amount of variation in GL in all parities. In parity 1, both breed of maternal grandsire and breed of service sire were significant while neither was significant in parities 2 and last. Average GL was similar between breeds within each parity except for Maine-Anjou service sires whose calves had shorter GL (table 1). It was not possible to test the effect of parity on GL, but by a comparison of the means in table 2, GL increased by almost 2 d from parity 1 to 2 and by 1 d or less from second to last parity. Bull calves were gestated between 1.4 and 1.8 d longer than heifers and between 5.4 and 7.6 d longer than twins. Both estimates of age of dam and type of pregnancy are in agreement with estimates reported by Andersen and Plum (1965).

Year-season and type of calf also explained a significant amount of variation in BD. Breeds of maternal grandsire and service sire did not contribute much variation. Maternal grandsire explained a significant amount of variation in parities 1 and 2 and service sire was a highly significant source of variation in all parities. Because BD is a function of GL, the effect of calf type on BD was

TABLE 1. LEAST-SQUARES MEANS AND STANDARD ERRORS OF GESTATION LENGTH, BIRTH DATE AND TIME TO FIRST OBSERVED ESTRUS FOR BREED OF MATERNAL GRANDSIRE, BREED OF SERVICE SIRE AND TYPE OF PREGNANCY.

	Gestation Length			Birth Date			First Observed estrus		
Item	Parity 1	Parity 2	Last Parity	Parity 1	Parity 2	Last Parity	Parity 1	Parity 2	Last Parity
Breed of maternal grandsire									
Simmental	281.4(.3)[a]	283.9(.5)	283.8(.5)	97.4(.8)	108.0(1.4)	106.8(1.1)	16.5(.4)	13.8(.6)	13.1(.7)
Limousin	282.3(.4)	283.5(.8)	284.5(.6)	98.6(1.7)	105.7(2.2)	107.8(1.4)	17.5(.7)	16.6(.8)	13.5(.9)
Maine-Anjou	280.5(.5)	283.9(1.0)	285.6(.7)	98.2(1.8)	105.9(2.8)	110.1(1.7)	16.9(.8)	14.0(1.1)	12.9(1.2)
Gelbvieh	282.0(.4)	282.4(.9)	284.7(.7)	94.2(1.7)	106.1(2.3)	108.8(1.7)	16.7(.5)	15.5(.8)	13.9(.8)
Breed of service sire									
Simmental	282.0(.3)	282.8(.5)	284.4(.5)	97.3(.8)	104.5(1.3)	108.7(1.1)			
Limousin	283.3(.5)	285.1(.9)	286.1(.8)	101.6(2.1)	111.9(2.4)	105.6(2.1)			
Maine-Anjou	280.9(.6)	281.2(1.4)	281.7(1.0)	97.7(2.9)	107.7(4.0)	102.8(2.4)			
Gelbvieh	283.0(.4)	285.1(.8)	283.5(.6)	100.5(1.8)	108.8(2.3)	107.9(1.6)			
Type of pregnancy									
Bull calf	284.3(.2)	286.9(.3)	287.2(.4)	97.8(.7)	109.4(.9)	111.2(. 9)			
Heifer calf	282.9(.2)	284.7(.3)	285.4(.4)	96.5(.7)	107.7(.9)	108.6(.9)			
Twin calves	278.9(.7)	279.3(.5)	280.1(.5)	93.9(1.8)	103.9(1.4)	103.2(1.3)			

[a]Mean(SE).

similar to that on GL. The large difference in BD between parity 1 and 2 (table 1) was due to the management practice of initiating the heifer breeding season 10 d earlier than that for the cows.

Total phenotypic variance and the variance associated with service sire were fairly consistent across all parities for GL (table 2). The heritabilities of direct additive effects, h^2_{Ao}, were moderately high (.36 to .45, table 2). Heritabilities for gestation length as a trait of the dam, h^2_{Ao}, were considerably smaller. Estimates of heritability of the maternal effects were .02 to .13. The covariance among sire means increased with parity for GL causing an increase in the estimated direct by maternal additive covariance and a decrease in the estimated additive maternal variance with parity. The resulting correlation between direct and maternal additive effects was negative in parities 1 and 2 but positive in the last parity (table 2). Negative estimates of the genetic correlation has been reported by Everett and Magee (1965), Philipsson (1976), Burfening et al. (1981) and Gaillard and Chavaz (1982).

The phenotypic variance for BD decreased with parity while the sire variance increased. This gave rise to direct effect heritability estimates which increased with parity (table 2). The estimates were smaller than those obtained for GL. The sire variance estimate in parity 1 was similar in magnitude to those obtained for GL in all parities. In the second and last parity, on the contrary, the BD sire variance estimates were more than twice those for GL. The additive maternal heritability decreased over parities and the estimate was negative in the last parity. The direct by maternal additive correlation was negative in parity 1, out of range in parity 2 and could not be estimated in the last parity.

Time to first observed estrus was significantly affected by year-season in all parities and also by breed of maternal grandsire and maternal grandsire in parity 2. As cows, daughters of Simmental and Maine-Anjou sires had a shorter FE, while Limousin-sired cows had the longest (table 1). The trait was analyzed as a trait of the dam. The estimated variance attributable to sires of the dams was small in parities 1 and 2 and negative in the last parity. The resulting heritability estimates were thus small (-.03 to .10).

EXPECTED RESPONSE TO SELECTION

Response to selection for earlier BD or shorter GL was studied by a deterministic simulation model. An index that maximizes the sum of the direct and maternal breeding value was used as the selection criterion (Van Vleck, 1970). The index utilized information on paternal and maternal half sibs as well as on progeny. The amount of information in the index was varied. The estimates of genetic variances and covariances were those of parity 1 for BD and an average of the estimates of the three parities for GL. Males were always mated to produce 25 viable progeny per year. The expected annual responses in BD and GL, using a two-stage selection scheme, achieved when males were selected on an index including information on their own record, 50 paternal half sibs, 3 maternal half sibs and 25 progeny and females were selected on an index that only differed in the amount of progeny (2 instead of 25) included in the index, were .76 d and 1.03 d, respectively. Using the parameter estimates of Everett and Magee (1965), Philipsson (1976), Burfening et al. (1981) and Gaillard and Chavaz (1982) for GL resulted in an expected annual response of between .60 and 2.10 d.

TABLE 2. HERITABILITIES WITH STANDARD ERRORS AND CORRELATIONS BETWEEN DIRECT AND MATERNAL ADDITIVE EFFECTS FOR GESTATION LENGTH BIRTH DATE AND TIME TO FIRST OBSERVED ESTRUS.

Estimate[a]	Parity 1	Parity 2	Last Parity
Gestation Length			
h^2_{Ao}	.41(.07)[b]	.45(.09)	.36(.07)
h^2_{MG}	.07(.03)	.09(.04)	.17(.05)
h^2_{Am}	.13	.03	.02
$r_{Ao.Am}$	-.72	-.46	.68
Birth Date			
h^2_{Ao}	.09(.03)	.17(.03)	.24(.06)
h^2_{MG}	.03(.02)	.08(.04)	.02(.03)
h^2_{Am}	.03	.01	-.11
$r_{Ao.Am}$	-.39	1.05	c
First Observed Estrus			
h^2_{MG}	.05(.02)	.10(.04)	-.03(.02)

[a] h^2_{Ao} = heritability of direct effects based on four times the service sire variance component, h^2_{MG} = heritability based on four times the maternal grandsire variance component (heritability of direct effects for first observed estrus since this is a trait of the dam), h^2_{Am} = heritability of additive maternal effects, $r_{Ao,Am}$ = correlation between direct and maternal additive effects.
[b] Standard errors in parenthesis.
[c] Not available since the estimate of the additive maternal variance was negative.

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