Brazilian Journal of Genetics, 18, 4, 541-545 (1995)
(Revista Brasileira de Genética)

Effects of fetal sex and sire and other factors on periparturient and postpartum performance of dairy cattle*

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ABSTRACT

Lactational and reproductive performance of 1580 dairy cows of five dairy breeds were analyzed to estimate the magnitude of effects on 20 response variables of the sires of fetuses born to initiate lactation. Data were from a single herd. Represented were daughters of 410 sires; number of lactation records per response variable varied from 1994 to 3776. Data were analyzed by method of ordinary least square analyses of variance in models which included random effects of sire of cow-year-season, sire of fetus in sire of cow, and a set of fixed effects, age of cow, length of record, sex of calf, days pregnant, birth weight and gestation length, and presence or absence of metritis, dystocia and retained placenta. Sire of fetus effects were detected in 16 response variables, accounting for 0 to 20.2% of the phenotypic variance. These estimates represented upper limits of the magnitude of sire of fetus effects since they included interactions of such effects with other factors. Effects of sire of fetus were not detected for uterine horn of pregnancy, retained placenta, stillbirth or death of calf prior to 30 days postpartum. Results thus confirm that sire of fetus effects exist for postpartum productive and reproductive performance of dairy cattle.

INTRODUCTION

Evidence that the fetus influences periparturient and postpartum performance of its dam, and that this ability is to some degree genetically determined, continues to accumulate (Adkinson *et al.*, 1977; Auran *et al.*, 1977; Johnson and Van Vleck, 1978; Taylor *et al.*, 1978, Pereira *et al.*, 1993). Skjerwold and Fimland (1975) were the first to detect such effects in a large data set. Bastos *et al.* (1993) estimated that sire of fetus (SOF) effects accounted for 0.81% of the total variance in milk yield, 1.67% for fat yield, 6.43% for fat % and 2.48% for lactation length. They did not detect effects of the interactions of SOF and sire of cow (SOC). Moya *et al.* (1989) obtained similar estimates for milk and fat yields and fat %, as well as for days open. In addition, Moya *et al.* (1991) detected interactions of SOC and SOF of about the same magnitude as the direct effects of SOF. Reis *et al.* (unpublished results) estimated SOF effects to represent 7.8% (days open), 1.2% (gestation length) and 8.7% (calving interval) of the total variance. The physiological basis of SOF effects has been described extensively (Stover *et al.*, 1978; Thatcher *et al.*, 1979; De Louis *et al.*, 1980; Wilcox, 1980).

MATERIAL AND METHODS

The basic data set for this research consisted of 3776 records collected at the University of Florida Dairy Research Unit during a 23-year period. The

* Florida Agricultural Experiment Station Journal Series No. R-04319.

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Research Unit is located 29°39.6'N, 83°49.6'W, and is classified as being within the latitudinal tropics and atmospherically within the subtropics (Byson and Hare, 1974). After screening, the data set consisted of 2999 records of 1580 cows; 410 sires and five breeds were involved. Not all records were complete for all variables; hence the number of records was variable. Most data (79%) were from Jerseys and Holsteins. Computer program was that of Harvey (1990). Major mathematical model included sire of cow-year-season category (SOCYS), SOF in SOCYS, and a set of fixed effects, as well as the error and overall mean. Several of the fixed effects were continuous variables, and included some or all of the following, as appropriate, each to the third order of polynomial regression: age of cow, length of record, days pregnant, birth weight of calf, and gestation length of calf. Additional discrete fixed effects included were sex of calf, uterine horn of pregnancy, and presence or absence of metritis, dystocia, and retained placenta; all represented binary data. Sex of calf and uterine horn of pregnancy also were examined as response (dependent) variables.

Since no crossbreeding had been practiced and was not involved in this data set, breed effects were confounded with SOCYS. Estimates of SOF effects would include the fetal sire effects and their interactions with SOC effects, and year and season effects, if any such existed. Since this study involved only a single herd, interactions involving SOF and herd likewise would be included in estimates of SOF effects. If SOF and SOC genetic effects were additive, their interactions would be expected to be zero (Van Vleck, 1978), however.

Table I - Mean performance, production and reproduction.

Trait[1]	Mean	Trait	Mean
Milk yield (kg)	4175	Acidity %	0.159
Fat yield (kg)	174	Chloride %	0.148
Protein yield (kg)	147	Protein/fat ratio	0.840
LM yield (kg)[2]	240	Birth weight (kg)	30.8
Fat %	4.38	Days to first service	78
Protein %	3.45	Days pregnant	141
LM %	5.55	Lactation length (days)	286

[1]Number of observations varies, 1994 to 2999.
[2]LM = lactose mineral.

Table II - Sex ratios, and frequencies of problems at parturition and uterine horn of pregnancy.

Trait[1]	Frequency	Trait	Frequency
Sex of calf		Stillbirth	0.079
Male	0.522	Retained placenta	0.055
Female	0.478	Uterine prolapse	0.003
Horn of pregnancy		Dystocia	0.025
Right	0.595	Metritis	0.107
Left	0.405	Alive at 30 d	0.849

[1]Based on 2795 to 3776 observations.

RESULTS AND DISCUSSION

Mean performance

Mean length of lactation was 286 days (Table I). Performance seemed representative for such a population in a subtropical environment at the time. Measures of reproductive performance refer to postpartum performance. Sex ratio, frequencies of problems at parturition, and frequency of pregnancies in left and right uterine horns are in Table II.

Males represented just over half of all births, agreeing with many estimates published for dairy cattle. Pregnancies occurred in the right uterine horn about 60% of the time, as suggested previously by Wilcox (1967). Problems at parturition ranged from uterine prolapse (rare) to metritis (more than 1/10). All cases of uterine prolapse involved first parturition animals. Stillbirths were defined as calves found dead or those which died within 24 hours postpartum.

Comparison of first-calf heifers and older cows

Three production (milk and fat yields, fat %) and five reproduction responses (birth weight, gestation length, stillborn, days to first service, and days pregnant) were selected in a preliminary study to compare SOF effects on heifers with those on older cows. Data set was 971 first lactation records and 1582 lactations from older cows. Results are not shown here. There was no evidence of differences in the magnitude of SOF effects between first calf heifers and older cows. Six of eight estimates were lower for first calf heifers. Estimates for milk and fat yields were slightly higher for first calf heifers. Thus no further attempt was made to study first calf heifers and older cows separately.

Effects of fetal sire

Effects of SOF, expressed as percentages of the total of the random effects in the model, were higher than most previous studies (Table III). Since they included SOF effects as well as their interactions, they agreed with estimates of Moya *et al.* (1989, 1991), however. They estimated the interactions to account for 9.0% of the variability in milk yield and 7.7% of the variability in fat yield.

Our estimates for protein and lactose plus mineral yields were also higher (Table III). Protein to fat ratios were also affected. Effects of SOF on birth weights represent nonmaternal additive genetic variance; heritability of birth weight has long been known to be high (Wilcox, 1980). Postpartum reproductive performance was also affected by SOF (days to first service and days pregnant during lactation) as noted by Reis *et al.* (unpublished results). If it is assumed that the multitude of interactions involving SOF effects is about equal to direct SOF effects, as shown by Moya *et al.* (1989, 1991), then the present estimates confirm those of Reis *et al.* (unpublished results).

Periparturient problems (dystocia, metritis, uterine prolapse) were affected by SOF, accounting for about 6-8% of the total variability (Table III). These estimates were obtained in spite of the fact that weight and sex of the calf were included in the model, along with other fixed effects listed. With these adjustments, no effect of SOF on occurrence of retained placenta could be detected. The semen donor (i.e., the SOF) did not affect the uterine horn of pregnancy. Stillbirth is known to have very low heritability, and this is shown by the estimate of zero in the present study.

Survival to 30 days postpartum was unaffected. Other problems at parturition were affected (dystocia, metritis, uterine prolapse) as well as were days to first service and days pregnant during lactation.

Effects of sex of calf and uterine horn of pregnancy

Milk yields were higher by 83 kg ($P < 0.05$) following birth of a male calf (Table IV), as suggested by Stonaker and Knapp (1974). Gestation lengths for males were one day longer than those for females, agreeing with numerous other studies; also, birth weights of males were 1.9 kg greater than females. The birth weights of calves were shown to be positively correlated with subsequent milk yield of the dams (Collier *et al.*, 1980). Estimates in the present study were adjusted for birth weights and sex of calf, as they were included in the mathematical model. Fat percentage (also corrected) seemed unaffected. Effects of uterine horn of pregnancy on these responses could not be detected, confirming work of Wilcox (1967).

CONCLUSIONS

Results indicate that a number of productive and reproductive performance of dairy cows are affected by SOF. Effects appear to be real and

Table III - Error variances and relative magnitude of variances of sire of fetus effects and their interactions.

Trait[1]	Error variance[2]	Ratio[3]	Trait	Error variance	Ratio
Milk yield	19,539	7.9	Birth weight	11.07	12.1
Fat yield	3,309	9.6	Horn pregnant	0.1660	0[4]
Protein yield	1,921	16.8	Retained placenta	0.0419	0
LM yield	6,676	14.6	Dystocia	0.0215	6.0
Fat %	0.1930	4.1	Metritis	0.0755	7.7
Protein %	0.0378	9.3	Uterine prolapse	0.0038	7.3
LM %	0.0396	7.8	Stillbirth	0.0680	0
Acidity %	261^{-6}	8.0	Alive 30 d	0.1212	0
Chloride %	42^{-6}	16.7	Days first service	630	19.4
Protein/fat ratio	0.0067	20.2	Days pregnant	6431	9.4

[1]Number of observations varies, 1994 to 2999.
[2]Error variances, σ^2_E.
[3]Ratio of sire of fetus effects and their interactions, $\sigma^2_{SOF\ (SOCYS)}$, to the sum $\sigma^2_E + \sigma^2_{SOF\ (SOCYS)} + \sigma^2_{SOCYS}$, expressed as percentages.
0[4]Represents negative estimate.
LM = Lactose mineral.

Table IV - Effects of sex of calf and uterine horn of pregnancy on several traits.

Trait	Calf sex			Uterine horn		
	n	Male	Female	n	Right	Left
Milk yield	2554	4214	4131*	1994	4291	4326
Fat %	2554	4.37	4.39	1994	4.23	4.20
Gestation length	2999	280.9	279.9	1994	281.2	280.4
Birth weight	1994	31.7	29.8*	1994	31.6	31.7

*$P < 0.05$; no other comparisons significant, $P > 0.15$.

measurable. No effects were found of SOF on the uterine horn of pregnancy of the cow, whether or not the parturition was associated with retained placenta, or whether or not the calf was stillborn or alive at 30 days postpartum.

ACKNOWLEDGMENTS

Assistance of Drs. F.G. Martin and R.C. Littell, Statistics Department, University of Florida, is gratefully acknowledged.

RESUMO

Foram analisados o desempenho lactacional e reprodutivo de 1580 vacas leiteiras de cinco cruzamentos de gado leiteiro para estimar a magnitude dos efeitos de 20 variáveis dos pais dos fetos nascidos para iniciar lactação. Os dados foram provenientes de um único rebanho. As filhas nasceram de 410 touros; o número de registros de lactação por variável foi de 1994 a 3776. Os dados foram analisados pelo método de análise de variância dos quadrados mínimos em modelos que incluíram os efeitos aleatórios de touro para vaca-ano-estação, pai do feto em (dentro de) pai da vaca, e um conjunto de efeitos fixos, idade da vaca, duração do registro, sexo do bezerro, dias de gestação, peso ao nascer e duração da gestação, e presença ou ausência de metritis, dystocia e retenção de placenta.

Efeitos do pai do feto foram detectados em 16 variáveis, num total de 0 a 20,2% da variância fenotípica. Estas estimativas representaram o limite superior da magnitude dos efeitos do pai do feto desde que incluídas interações de tais efeitos com outros fatores. Efeitos do pai do feto não foram detectados quanto ao lado do útero, retenção de placenta, morto ao nascer, ou morte do bezerro nos primeiros 30 dias após nascimento. Resultados confirmam que efeitos do pai do feto existem para o desenvolvimento produtivo e reprodutivo após o parto em gado de leite.

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(Received January 30, 1995)