Components of Variance Associated with Service Sire for Milk Yield and Reproductive Traits

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ABSTRACT

The association of service sire or sire of fetus with three milk yield traits and two reproductive intervals were investigated. Two procedures for estimation of variance components, Henderson's Method 1 and Method 3, were applied to a model of herd-year-season, sire of cow, and service sire. Analyses were for sire of calf born to initiate second lactation and service sire of the cow in second lactation. About 11,000 second lactation records on Holstein cows were available after editing for breeding and calving dates. Service sires and sires of cows were required to be in artificial insemination. Estimates by Method 1 for gestation length and days open were 6.0% and −.2% of total variance for sire of calf and 1.0% and 5.4% for service sire in second lactation. Method 1 estimates were consistently larger than Method 3 for milk yield. Variance components expressed as percent of total variance for mature equivalent milk yield in 305 days, 150-day milk yield, and milk yield in remaining days of lactation were 2.7%, 3.1%, and 1.7% for sire of calf and 2.7%, 3.8%, and 1.3% for service sire in second lactation. These same components from Method 3 were .8%, .4%, .8%, and 1.0%, 1.6%, .6%. The differences in estimates may reflect nonrandom use of service sires across herd-year-seasons and sires of cows. About 1% of variance in milk yield was associated with service sires.

INTRODUCTION

Considerable interest has been generated recently by studies associating sire of fetus with the dam's milk production subsequent to birth of the calf. The relatively wide range in estimates of components of variance associated with the sire of fetus (SOF) has caused uncertainty as to economic implications of such an effect (13). Endocrine and genetic models for SOF effect have been proposed and discussed (1, 8, 9, 10, 11, 12). Table 1 presents a brief summary of work on effect of SOF related to lactational milk yield subsequent to parturition.

Skjervold and Fimland (8) in Norway reported a SOF effect from survey data. Their study involved 48,852 first lactation records over 4 yr. The 250 to 350 sires of fetuses used annually were test bulls in a young sire sampling program and, therefore, probably were sampled randomly across herds and sires of cows. Skjervold and Fimland applied a random model to data adjusted for age and herd effects, used Henderson's Method 1, and found about 1% of the variance in milk yield associated with SOF. Adkinson et al. (1) reported on similar analyses in which records for all lactations were included. Since his lactation records were from the Dairy Herd Improvement program, there was more opportunity for nonrandom use of SOF or service sires across herds and sires of cows than in the Norwegian study, which may explain in part the larger estimate of approximately 8%. More recently, Wickham (14) completed a smaller study in which 1 yr of production information on cows in second and greater lactation was examined. The sires of fetuses or service sires were in an AI "bull of the day" program so that it seems likely that service sires were used randomly. Wickham's model contained fixed effects for herds as well as random SOF effects. The small numbers of service sires permitted application of a MINQUE procedure for variance components (6) which gave an estimate of approximately 1% of variation in milk yield associated with SOF. In summary, the three studies have provided a wide range in estimates of variation in lactational milk yield related to SOF effect.

Therefore, the objectives of this study were

Received August 14, 1978.

TABLE 1. Summary of sire of fetus studies on milk yield.

Reference	Data	Variance component estimation procedure	% Total variance associated with sire of fetus
Skjervold and Fimland (8)	4 yr 48,852 first lactations 256 to 357 test sires/yr Norwegian Red	Method 1	1.0
Adkinson et al. (1)	7 yr 27,200 all lactations 2080 numerically-identified sires Holstein	Method 1	8.2
	7 yr 3,731 all lactation 432 numerically-identified sires Jersey	Method 1	11.8
Wickham (14)	1 yr 3,364 ⩾ second lactation 15 AI sires Holstein	MINQUE	.9
	1 yr 4,223 ⩾ second lactation 32 AI sires Jersey	MINQUE	1.1

to 1) replicate previous work, 2) investigate other traits and factors involved with SOF, and 3) compare methods of variance component estimation when the SOF effect may be associated with other elements of the model.

MATERIALS AND METHODS

Five traits were studied. Two were reproductive intervals, gestation length of pregnancy leading up to second calving (GL) and subsequent days open during second lactation (DO); and three involved second lactation milk production, 305-day mature equivalent milk yield (305 ME), first 150-day milk yield (150 ME), and remaining yield in lactation beyond day 150 (REM ME). All three traits of milk yield were twice daily milk and age-season adjusted to mature equivalent.

Data consisted of second lactation records 150 days or more in length on Holstein cows 28 to 52 mo of age enrolled in the official Dairy Herd Improvement (DHI) program and calving from 1970 to 1977. Editing for close agreement between breeding and calving date in addition to requiring the sires of cows and service sires to have been used in AI reduced the available data from 1.9 million in the active herd file of the New York DHI Cooperative/Dairy Records Processing Laboratory to 47,737 records. A further restriction to a connected subset (6) provided approximately 11,000 records for study.

Model

Factors considered in the model were sire of cow, herd-year-season of freshening, and one of two service sires. The first service sire (SS1) was the sire of the fetus or sire of calf whose birth initiated the cow's second lactation. The second service sire (SS2) was the bull that the cow was bred to during the second lactation or the sire of the fetus that the cow carried during later stages of her second lactation.

The model applied for each analysis of service sire for all five variables was

$$y_{ijkl} = \mu + h_i + s_j + (hs)_{ij} + ss_k + e_{ijkl}$$

where

μ is a constant,

h_i is the ith random herd-year-season effect, $IID(0,\sigma_h^2)$,

s_j is the jth random sire of cow effect, $IID(0,\sigma_s^2)$,

$(hs)_{ij}$ is the random interaction effect associated with the ith herd-year-season and jth sire of cow, $IID(0,\sigma_h^2 s)$,

ss_k is the kth random service sire effect, $IID(0,\sigma_{ss}^2)$, and

e_{ijkl} is the residual error effect, $IID(0,\sigma_e^2)$.

The usual assumptions are that the covariances among all random effects are zero. Although not an assumption of the model, randomness in joint occurrence of levels of elements of the model generally is implied: e.g., sires of fetuses are used randomly across all herds or on daughters of sires of cows.

Variance Component Procedures

The approach taken was to do four analyses, two variance component procedures for each of the two types of service sires. The first procedure used Henderson's Method 1 to obtain variance component estimates (3). The usual sums of squares or reductions (R) for each component of the model were computed and equated to their expectation as follows:

$$\begin{bmatrix} R(\mu) \\ R(\mu,h) \\ R(\mu,s) \\ R(\mu,hs) \\ R(\mu,ss) \\ (y'y) \end{bmatrix} = \underset{\sim}{K} \begin{bmatrix} \hat{\mu}^2 \\ \hat{\sigma}_h^2 \\ \hat{\sigma}_s^2 \\ \hat{\sigma}_{hs}^2 \\ \hat{\sigma}_{ss}^2 \\ \hat{\sigma}_e^2 \end{bmatrix}$$

where $\underset{\sim}{K}$ is the matrix of coefficients of the variance components in the expectations of the sums of squares.

Since the results of a Method 1 analysis (3) used by Johnson and Van Vleck (5) on a less rigidly edited sample of the data indicated association of some kind, Henderson's Method 3 also was applied to remove effects of such association. This second procedure involved computing sequential reductions in sums of squares and then equating them to their expectations (3).

To simplify the computations, herd-year-season, sire of cow, and their interaction were combined into a herd-year-season by sire of cow subclass. Therefore, only the following two reductions were computed since variance component estimates for service sire and error would be the same as if all five variance components had been estimated.

$$\begin{bmatrix} R(\mu,h,s,hs,ss) - R(\mu,h,s,hs) \\ (y'y) - R(\mu,h,s,hs,ss) \end{bmatrix} = \underset{\sim}{L} \begin{bmatrix} \hat{\sigma}_{ss}^2 \\ \hat{\sigma}_e^2 \end{bmatrix}$$

where $R(\mu,h,s,hs,ss) - R(\mu,h,s,hs)$ is equivalent to $R(ss/\mu,h,s,hs)$, which was computed as the sum of products of service sire solutions and absorbed right-hand sides for service sires.

RESULTS AND DISCUSSION

The data is selective as evident by the high milk yield shown by means in Table 2. Adkinson et al. (1) also found this in their study. In addition, the average days open is indicative of high herd management, due possibly to the requirement of accurately reported sire and service sire information.

Results for Method 1 for both SS1 and SS2 are in Table 3. Usual estimates of variance for herd-year-season and sire of cow were obtained. However, the sire of fetus or SS1 component of 2.7% for 305 ME is intermediate to previously reported estimates of 8% (1) and 1% (8) and is smaller than the estimate of 3.8% by Johnson and Van Vleck (5). The variance component estimated for SS2 effect was larger than for SS1 effect for the 150 ME milk yield variable, which is surprising since the conceptus or fetus has little known effect on the dam earlier than 60 days postconception. Therefore, that SS2 could have a causative impact on 150 ME milk yield seems unlikely. There may be, however, a relationship between SS2 and the cow's production. For example, if dairymen were able to evaluate the cow phenotypically after her first and early second lactation milk yields and then selectively choose a service sire based on this evaluation, an associa-

TABLE 2. Means and their standard errors (SE) for the five variables and number of cows in the two analyses for sire of calf (SS1) and service sire in second lactation (SS2).

Variable	Analysis			
	Sire of calf (SS1)		Service sire in second lactation (SS2)	
	Mean	SE	Mean	SE
305 ME milk yield (kg)	7608	14	7613	14
150 ME milk yield (kg)	4583	8	4582	8
REM ME milk yield (kg)	3024	8	3031	8
Gestation length (days)	278.5	.1	278.5	.1
Days open	104.3	.5	105.3	.5
Number of cows[a]	10,519		10,961	

[a]Number of cows differ between two analyses due to some cows having only one of the service sires identified.

tive source of variance would appear in the SS2 component. A recent study (2) also found a small effect associated with SS2 on production in the later stages of lactation. Estimates for the two reproductive interval traits agree closely with other values reported in the literature.

When Method 3 was applied to the same data, a large reduction in amount of variation

TABLE 3. Method 1 variance components for the five variables expressed as percentages of total variance for the analyses with sire of calf (SS1) and service sire in second lactation (SS2).

Variance component	Number of levels	305 ME milk yield	150 ME milk yield	REM ME milk yield	Gestation length	Days open
Analysis for sire of calf (SS1)						
SS1	761	2.7	3.1	1.7	6.0	−.2
Sire of cow	394	5.1	4.4	6.0	4.9	.9
Herd-year-season	3401	35.3	42.0	26.6	3.0	4.3
Sire x herd-year-season	4324	1.8	1.2	1.7	−1.0	2.7
Error		55.2	49.4	64.0	87.2	92.4
Total variance		2,095,142[a]	619,287[a]	687,123[a]	38.0[b]	2275.9[b]
Analysis for service sire in second lactation (SS2)						
SS2	803	2.7	3.8	1.3	1.0	5.4
Sire of cow	407	5.2	4.3	6.1	4.8	.7
Herd-year-season	3493	36.4	42.9	27.4	3.3	3.7
Sire x herd-year-season	4528	−.3	−.4	.0	.1	2.5
Error		56.0	49.4	65.2	90.8	87.6
Total variance		2,093,941[a]	617,282[a]	688,041[a]	37.3[b]	2360.9[b]

[a]kg^2.

[b]$days^2$.

TABLE 4. Method 3 variance components for the five variables expressed as percentages of total variance for the analyses with sire of calf (SS1) and service sire in second lactation (SS2).

Variance component	Number of levels	305 ME milk yield	150 ME milk yield	REM ME milk yield	Gestation length	Days open
Analysis for sire of calf (SS1)						
SS1	761	.8	.4	.8	4.9	−.2
Error		99.2	99.6	99.2	95.1	100.2
Total variance		1,209,093[a]	323,542[a]	450,956[a]	35.4[b]	2097.7[b]
Analysis for service sire in second lactation (SS2)						
SS2	803	1.0	1.6	.6	1.2	8.1
Error		99.0	98.4	99.4	98.8	91.9
Total variance		1,225,209[a]	327,274[a]	456,678[a]	34.2[b]	2200.1[b]

[a] kg^2.

[b] $days^2$.

accounted for by service sires was evident in the three milk yield traits (Table 4). The reduction is probably due to Method 3's ability to eliminate associative effects of nonrandom usage of service sires across herds and sires of cows in this survey population (4,7).

These results agree with previous estimate of SOF effect in the following way. When Method 1 was applied to survey data that may have reflected nonrandom use of service sires by dairymen, larger estimates of variation associated with sire of fetus were obtained. However, when Method 1 was applied to survey data in which service sires were used randomly or when Method 3 or mixed model procedures were applied so that associative variance was not included in the estimated variance component for SOF, then the estimates of the amount of variance in milk yield accounted for by service sires were about 1% or less.

SUMMARY AND CONCLUSIONS

Two procedures of estimation of variance components were applied to the same connected data set of second lactation records. Estimates of variance component for SOF or service sire differed between the two procedures, which was probably due to nonrandom mating of service sires across herds and sires of cows. Henderson's Method 3 variance component procedure seemed better able than Method 1 to estimate the components free of associative effects.

Our primary conclusion was that the magnitude of estimates of variance components for sire of fetus or service sire may depend on the method used to analyze the data. Further studies are needed to replicate estimates of SOF effects for other data sets and variance component procedures. It is generally known, but may be important to emphasize, that a survey study cannot determine if the sire of the fetus has a causative effect on milk yield of the dam. A large, well-designed experiment would be needed to answer that question. The results also may indicate a need for investigation of nonrandom use of service sires as it affects current methods of dairy sire evaluation.

ACKNOWLEDGMENTS

This study was supported in part by a grant from Eastern Artificial Insemination Cooperative, Inc.

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