Joint Genetic Analysis of Conception and Maintenance of Pregnancy in Dairy Cattle Using a Linear-Threshold Model

A.S. Leaflet R2303

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Summary and Implications

A joint analysis of days open and calving success was implemented to further enhance the identification of cows with greater genetic merit for reproductive performance. Calving success is a categorical trait with similar genetic variation as days open and is analyzed jointly with days open to make effective use of the positive genetic correlation between these two traits. The joint analysis can identify cows with greater genetic merit for conception at an earlier stage of lactation and greater success at maintenance of pregnancy. The joint analysis also enhances the reliability of detecting true genetic differences between cows for fertility because it makes more effective use of all data.

Introduction

An unbiased genetic analysis of days open (DO) may include fertility records from cows that did not calve in a subsequent parity (Van Raden, personal communication, 2004). Survival analysis and linear models adapted for analysis of censored data were recently proposed to estimate sire's breeding values for days open in dairy cattle (Gonzales-Recio et al., 2006). Both types of analyses gave similar sire ranking, but a linear model adapted for analysis of censored data was found to be easier to implement for the magnitude and scope of a national genetic evaluation program for DO as the reproductive outcome of the interval from calving to subsequent conception on rebreeding (Gonzales-Recio et al., 2006). In a censored modeling approach, data missing for the trait of inference are replaced by using imputation (Urioste et al., 2007) or data augmentation (Gonzales-Recio et al., 2006; Urioste et al., 2007) methodology on the same trait. Recently, a bivariate linear-threshold approach was used to account for censored data in the analysis of a reproductive trait in beef cattle (Urioste et al., 2007). Application of this approach assumes that one trait follows an underlying continuous distribution and that it can be analyzed by using a linear model e.g., calving date, and that it is censored by a correlated categorical trait (e.g. calving success: 1=success; and 0=failure). The idea of using a similar two-trait analysis to account for conception and maintenance of pregnancy as being suitable for use in the analysis of fertility traits in dairy cattle was called to our attention by I. Misztal (personal communication, 2007)

The objective of this study was to implement an analysis of female fertility to address the nature of complex correlated traits like conception(DO) and maintenance of pregnancy (CS) by using a bivariate linear(DO)-threshold model(CS) for parity 1 and 2, separately.

By design, the analysis addresses the correlated nature of 1) conception (DO); and 2) maintenance of pregnancy (CS) with adjustment for censoring to make more effective use of all data on every cow. The underlying hypothesis is that allowance for censoring is better than ignoring censoring because deletion of missing values can be interpreted as a form of pre-selection on a trait correlated with DO.

Materials and Methods

Data were collected at the Ankeny dairy research farm at Iowa State University from 1986 to 2004. A total of 1049 and 699 records from first and second parity Holstein cows were used in the analysis (Table 1). All cows were required to have a previous calving.

Days open was defined as days from calving to conception, and calving success was defined as ordered categorical variable (1=success, 2= failure to calve with opportunity, and 3= failure to calve without opportunity to calve). Missing values for days open were included in category 2 or 3 of calving success. The procedure for assigning values to calving success follows:

<u>Category</u> <u>Rule</u>

1=success If a cow has conceived and calved.

2=failure with opportunity

If a cow was culled for infertility (e.g., Chronic cystic ovary and infertility-not known reason).
If a cow died or was culled for non reproductive reasons and one of the following conditions was observed:
- If the interval from conception to date leaving herd (CONL) was greater than 280 d (Gestation length).
- If CONL was missing and the interval from first breeding to date leaving herd (FBL) was greater than 189 d.
- If FBL was missing and the interval from last calving to date leaving herd (PCL) was greater than 90 d.

3=failure without opportunity

The remaining cows. This category includes cows that were alive at the end point of data collection.
* 90 and 189 d were about 90th percentile for PCL and FBL, respectively.

Genetic parameters for DO and CS were estimated by using a bivariate linear(DO)-threshold(CS) animal model for parity 1 and parity 2, separately.

Outcome of genetic predictions were adjusted for line of sire selection (high or average PTA-fat- plus- protein) and age at calving (11 and 16 levels for parity 1 and 2, respectively) as fixed effects . Random effects were year-season (54 and 56 levels for parity 1 and 2, respectively). The pedigree file included 9178 animals.

Analyses were implemented by using THRGIBBS2F90 (Tsuruta, 2007). POSTGIBBSSF90 and a visual inspection of trace plots for a chain of 200,000 samples was used to determine the burn-in length, number of samples and thinning ratio. For both parity analyses a chain of 200,000 samples was run, with a burn-in of 50,000 samples, keeping every 1,000th sample. The mean and standard deviation of the remaining samples then were used to obtain estimates of variance components, the genetic correlation, and heritability.

Results and Discussion

Table 1 gives the number of records for DO and CS. One clear advantage of adding CS as a trait correlated with DO is the larger effective number of records for CS than the number of records for DO alone; 27% increase in parity 1 and 25% in parity 2. This shows that there was a larger pool of cows in the joint analysis that if DO was analyzed as a single trait.

Tables 2 and 3 give the distribution of scores for CS by line and parity. The percentage incidence of CS=1 was relatively consistent across lines and parity groups. The percentage of failure with opportunity increased from 8 to 10% in the AFP line and from 9 to 13% in the HFP line from first to second parity. Also there was a higher percentage of failure with opportunity associated with sire selection for high PTA-fat + protein. Early embryonic mortality accumulated over 18yr explains the cause of pregnancy failure with opportunity. The definition of CS as a correlated categorical variable has enabled us to partition DO into groups of cows that account for partial failures of 8% to 9% in parity 1 and 10% to 13% in parity 2 and complete failures of 25 to 24 % or 23 to 21%.

Table 4 gives heritability and genetic correlation estimates for DO and CS. Heritability estimates for DO were 2.4 to 2.9 times larger in this analysis than estimates obtained by the random regression procedure ignoring censoring reported earlier (Gutierrez et al., 2007). CS also had substantial genetic variation with heritability estimates of 0.16, 0.10, and 0.24 for nullparous heifers, 1st and 2nd parity cows, respectively.

Table 1. Number records for day open and calving success by parity.

	Parity		
	0	1	2
Days open	…	766	528
Calving success	1236	1049	699

Table 2. Number (percentage) of primaparous cows for calving success by selection line in parity 1.

Calving success	AFP	HFP
1	299 (67%)	400 (67%)
2	38 (8%)	54 (9%)
3	111 (25%)	147 (24%)
Total	448	490

Table 3. Number (percentage) of multiparous cows for calving success by selection line in parity 2.

Calving success	AFP	HFP
1	201 (67%)	265 (66%)
2	29 (10%)	50 (13%)
3	69 (23%)	85 (21%)
Total	299	400

Table 4. Heritability[1] and genetic correlation estimates for days open (DO) and calving success (CS).

	Parity		
	0	1	2
Days open (h^2)	-	0.17 (0.06)	0.20 (0.07)
Genetic correlation $r_{DO,CS}$	-	0.32 (0.40)	0.21 (0.20)
Calving success (h^2)	0.16 (0.06)	0.10 (0.05)	0.24 (0.07)

[1] Mean and (posterior standard deviation).

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