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Genotype by environment interaction for the interval from calving to first insemination with regard to calving month and geographic location in Holstein cows in Denmark and Sweden

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ABSTRACT

The objectives of this study were to investigate genotype by environment interaction effects, with environments defined as calving month and geographic location, on the interval from calving to first insemination (CFI) of Holstein cows in Denmark and Sweden. The data set included 811,285 records on CFI for first-parity cows from January 2010 to January 2014 housed in 7,458 herds. The longest mean CFI was 84.7 d for cows calving in April and the shortest was 76.3 d for cows calving in September. The longest mean CFI of 87.1 d was recorded at the northernmost location (LOC-8), whereas the shortest mean CFI of 73.5 d was recorded at the southernmost location (LOC-1). The multiple trait approach, in which CFI values in different calving months and different geographic locations were treated as different traits, was used to estimate the variance components and genetic correlations for CFI by using the average information (AI)-REML procedure in a bivariate sire model. Estimates of genetic variance and heritability were highest for January calvings and 3 times smaller for June calvings. Location 2 had the highest heritability and LOC-8 the lowest, with heritability estimates decreasing from LOC-2 to LOC-8. Genetic correlations of CFI between calving months were weakest between cold months (December and January) and warm months (June, August, and September); the lowest estimate was found between January and September calvings. Genetic correlations of CFI between the different geographic locations were generally strong, and the weakest correlation was between LOC-3 and LOC-8. These results indicate a genotype by environment interaction for CFI primarily regarding seasons described by calving months. The effect of geographic location was less important, mostly producing a scaling effect of CFI in different locations. We concluded that CFI is more sensitive to seasonal effects than geographic locations in Denmark and Sweden.
Key words: interval from calving to first insemination, female fertility, genotype by environment interaction, calving month, geographic location

INTRODUCTION

Reduced fertility of dairy cows has a great effect on the overall dairy cattle industry because it is a major reason for increased number of inseminations, higher veterinary costs, and culling of dairy cattle, all of which negatively affect profitability (De Vries, 2006). The global use of AI in the dairy industry raised concerns about reranking of sires across different environments as a consequence of genotype by environment (**G × E**) interactions (Falconer and Mackay, 1996). Such effects also could be important for dairy farmers within a country, because farmers could choose those sires best suited to the local production environment (Kolmodin et al., 2002; Strandberg et al., 2009).

A G × E interaction exists when the capacity to alter the phenotype in response to changes in the environment differs among animals (Falconer and Mackay, 1996). The common ways to investigate the existence of a G × E interaction are to use a multiple trait approach or a reaction norm approach with a random regression model. The multiple trait approach can be used when the environment is divided into distinct classes and analyzed as different traits, and a genetic correlation significantly different from unity identifies the existence of a G × E interaction (Falconer, 1952; Falconer and Mackay, 1996). For example, the multiple across-country evaluation method considers each country as a different environment, and the correla-

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tion of the same trait expressed in different countries is estimated (Schaeffer, 1994). Reaction norm models have been used to describe effects that change over a continuous scale, and the genotype effect is modeled as a function of the environment, called the reaction norm, which results in heterogeneous variance components and heritability with the change of environment (Kolmodin et al., 2002; Schaeffer, 2004).

Fertility traits are heavily influenced by environmental factors such as seasons (or months) of calving and geographical region. For example, days open for cows calving in September were 50 d shorter than for March calvings in US Holsteins (Oseni et al., 2004). A similar effect on days open was found in Thai Holstein crossbreds, where cows calving in March remained open 40 d longer than cows calving in October (Boonkum et al., 2011). Sensitivity to seasonal effects on conception rates was also found by Huang et al. (2008), who reported that US Holstein cows in New York inseminated in March and April have 10% higher conception rates than cows inseminated in May and June. Furthermore, modifying the environment to improve reproductive performance has been reported. For example, a shorter interval from calving to first estrus, fewer days open, shorter calving interval, and fewer AI services required per cow were achieved by exposing cows calving in winter and fall to supplementary light at night (Hansen and Hauser, 1984; Reksen et al., 1999). Sensitivity to geographic regions within a country was reported by Oseni et al. (2003), who found days open in the southeastern United States to be 18 d longer than in the southwest. Similarly, days open for Swedish Red and White cows in southern parts of Sweden was 10 d shorter than in the northern parts of Sweden (Kolmodin et al., 2004).

The effect of geographic regions on the genetic variation of fertility traits, expressed as different countries, is reported by using a multiple across-country evaluation. Heterogeneous genetic variance and heritability estimates of the interval from calving to first insemination (**CFI**), days open, and interval from first to last insemination were estimated between Canada, the United States, Spain, Belgium, Switzerland, Germany, Austria, and joint Nordic countries (Denmark, Finland, and Sweden); however, the estimated genetic correlations of the same trait in different countries did not significantly differ from unity (Nilforooshan et al., 2010). On the other hand, genetic correlations less than unity were found for age at first calving between Brazil and Colombia (Cerón-Muñoz et al., 2004). Within Australia, Haile-Mariam et al. (2008) studied the effect of geographic regions on CFI and calving interval in Holstein cows across 3 geographic regions using the multiple trait approach and found heterogeneity of heritability estimates. However, the estimated genetic correlations of the same traits in different regions were very high and close to unity. An effect of seasonal change on fertility, expressed as calving month, was reported by Oseni et al. (2004), who found heterogeneity of both genetic variance and heritability estimates of days open in US Holstein cows across calving months using the reaction norm model, with the highest genetic variance and heritability estimates obtained in March calvings and the lowest in September calvings. The lowest estimate of genetic correlation of 0.78 was found between summer and fall calvings, indicating small changes in the ranking of animals across different calving months. Another monthly pattern of variance components and heritability estimates of days open was reported in Thai Holstein crossbreds by Boonkum et al. (2011), where the highest values for genetic variance, residual variance, and heritability estimate were found for March calvings and the lowest for October calvings.

Calving to first insemination interval is an economically important trait in the Nordic total merit index because it measures the cow's ability to return to cyclic estrus after calving. Furthermore, the trait is also correlated with the cow's ability to conceive early following insemination and become pregnant. For example, Haile-Mariam et al. (2003) reported that cows with a shorter CFI have higher pregnancy rates, shorter calving intervals, and higher first insemination nonreturn rates. The estimated genetic correlations between CFI and pregnancy rate, calving interval, and first insemination nonreturn rate were −0.84, 0.55, and −0.69, respectively. Although the importance of CFI and the effect of seasonal change and geographic location on fertility traits are well documented in the literature, no studies have been conducted on the genetic variation and the G × E interaction due to seasons of calving and geographic location on CFI. The objectives of the current study were to investigate the changes of genetic parameters and the existence of G × E interactions for CFI in relationship to season (i.e., calving month) and geographical location in Holstein cows in Denmark and Sweden.

MATERIALS AND METHODS

Design, Animals, and Data

The fertility trait used in the present study was CFI. Calving months and geographic locations based on the north-south distance from the equator were treated as different traits using the multiple trait approach to estimate genetic parameters and genetic correlations.

The insemination records for Holstein cows in Denmark and Sweden were obtained by the Nordic Cattle Genetic Evaluation NAV (SEGES, Aarhus, Denmark).