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Estimation of variance components and genetic trends for twinning rate in Holstein dairy cattle of Iran

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ABSTRACT

Calving records from the Animal Breeding Center of Iran, collected from January 1991 to December 2007 and comprising 1,163,594 Holstein calving events from 2,552 herds, were analyzed using a linear animal model, linear sire model, threshold animal model, and threshold sire model to estimate variance components, heritabilities, genetic correlations, and genetic trends for twinning rate in the first, second, and third parities. The overall twinning rate was 3.01%. Mean incidence of twins increased from first to fourth and later parities: 1.10, 3.20, 4.22, and 4.50%, respectively. For first-parity cows, a maximum frequency of twinning was observed from January through April (1.36%), and second- and third-parity cows showed peaks from July to September (at 3.35 and 4.55%, respectively). The phenotypic rate of twinning decreased from 1991 to 2007 for the first, second, and third parities. Sire predicted transmitting abilities were estimated using linear sire model and threshold sire model analyses. Sire transmitting abilities for twinning rate in the first, second, and third parities ranged from −0.30 to 0.42, −0.32 to 0.31, and −0.27 to 0.30, respectively. Heritability estimates of twinning rate for parities 1, 2, and 3 ranged from 1.66 to 10.6%, 1.35 to 9.0%, and 1.10 to 7.3%, respectively, using different models for analysis. Heritability estimates for twinning rate, obtained from the analysis of threshold models, were greater than the estimates of linear models. Solutions for age at calving for the first, second, and third parities demonstrated that cows older at calving were more likely to have twins. Genetic correlations for twinning rate between parities 2 and 3 were greater than correlations between parities 1 and 2 and between parities 1 and 3. There was a slightly increasing trend for twinning rate in parities 1, 2, and 3 over time with the analysis of linear animal and linear sire models, but the trend for twinning rate in parities 1, 2, and 3 with threshold animal model analysis was decreased over the years. There was a significant decreasing trend for twinning rate in parities 1 and 2 over time with the threshold sire model analysis, but the genetic trend for twinning rate in parity 3 with this model of analysis was significant and positive. In general, there were increasing genetic trends for twinning rate from parities 1 through 3 using different models of analysis.

Key words: twinning rate, linear model, threshold model, genetic trend

INTRODUCTION

Rate of reproduction has a major impact on life-cycle costs of production of different animal species and on their competitiveness for different types of production resources. High-producing dairy cows produce 5 times as much milk protein per unit of feed as beef cattle (Reid et al., 1980).

However, twin birth is disadvantageous for most beef and dairy producers because of its association with several unfavorable effects, including lower potential calf survival and poorer cow reproductive performance (Fricke, 2001). Twinning is also associated with increased dystocia (because of malpresentation), increased incidence of retained placenta, higher mortality rates, frequent occurrence of freemartins, and longer intervals from parturition to first estrus (Kirkpatrick, 2002; Silva del Río et al., 2007).

The results of numerous surveys and studies have generally been consistent in identifying problems associated with twinning, except for dystocia. Inconsistent results for incidence of dystocia may reflect 2 competing dynamics: twinning reduces the incidence of dystocia attributable to large calf size but increases the incidence of dystocia attributable to malpresentation (Kirkpatrick, 2002). Dairy cows may give more milk in the lactation resulting from a twin birth (Syrstad, 1974), but cows calving twins are at greater risk for metabolic disorders, including displaced abomasum and ketosis (Fricke, 2001). In addition, increased frequency of twinning would increase the potential for obtaining more progeny from a genetically superior female, thereby allowing those females to play a larger role in a selection program (Cady and Van Vleck, 1978). The

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Table 1. Summary of pedigree information

Animals in total	Inbred animals	Sires	Dams	Animals with progeny	Animals without progeny	Base animals	Non-base animals
497,216	208,201	8,007	242,176	250,183	247,033	87,444	409,772

importance of this condition can be expressed along with the application of technologies controlling the sex of calves. In other words, the use of embryo technologies and sexed semen leads to significantly more female calves. This allows dairy producers to select among the potential dams of their herd and produce dairy replacement heifers from only the genetically superior animals, and it promotes enhanced rates of genetic gains (De Vries et al., 2008).

Individuals with high twinning rates still appear, especially in the Holstein breed. Protection of recessive alleles may explain the repeated occurrence of high-twinning individuals; however, Van Vleck and Gregory (1996) reported no dominance effects for ovulation rate in beef cattle, a trait closely related to twinning. Gregory et al. (1990) concluded that twinning rate is a quantitative trait that has an underlying continuous expression involving many loci. Continued increases in milk production over the last 2 decades in dairy herds have been associated with an increase in twinning rate (Kinsel et al., 1998; Wiltbank et al., 2000). Wiltbank et al. (2000) proposed that high milk production increases steroid metabolism because of an increased blood flow to the digestive tract and the liver. The subsequent metabolism of the steroid estradiol slows the natural decline in FSH, which means that follicles have more time to undergo physiological changes before ovulation (Wiltbank et al., 2000). The lactation number and level of milk production of the cow appear to be positively associated with increased ovulation rate and twinning (Fricke and Wiltbank, 1999; Wiltbank et al., 2000).

Syrstad (1974) estimated the heritability and repeatability of twinning in Norwegian dairy cattle to be $2.2 \pm 0.2\%$ and $6.0 \pm 0.7\%$, respectively. Additionally, Syrstad (1974) transformed the 2.2% heritability on a binomial scale to 23% for an underlying continuous variable using the formula from Van Vleck (1971). This could be an overestimation because twinning occurs less than 20% of the time (Van Vleck, 1971). Ron et al. (1990) reported the twinning rate in Holsteins to be 4.8 and 6.9% for second- and third-parity cows, respectively. They estimated heritability to be 10.1% when using a threshold model, but only 2.2% when using a linear model. Repeatability estimates were 55 and 30% for the sire and maternal grandsire models, respectively.

According to Ron et al. (1990), the twinning rate of Holsteins increased from 4.5 to 5.6% during a 20-yr period along with increasing milk production. The small estimates of heritability (<0.l0) for twinning rate, which agreed with the literature reviewed by Gregory et al. (1990), as well as the long generation interval and high resource requirement to obtain measures of the twinning rate, led to the suggestion to use ovulation rate in pubertal heifers to select indirectly for twinning rate (Echternkamp et al., 1990). In most analyses, repeatability has been estimated to be less than heritability; this has been postulated to arise from small negative environmental covariances in adjacent gestations or estrous cycles. Generally, most studies involving analyses of field data have reported that heritability of single-parity twinning rate is low, averaging approximately 0.04. Syrstad (1984) estimated heritability for twinning as 0.006 in the first parity, increasing to approximately 0.04 in parities 3 to 5 when using Norwegian data collected from 1978 to 1981. In some countries where male calves from dairy operations are raised for beef production, increasing the twinning rate is one causative effect of increasing beef production. There is much genetic potential to improve dairy production by selection for or against the incidence of twinning, and this highlights

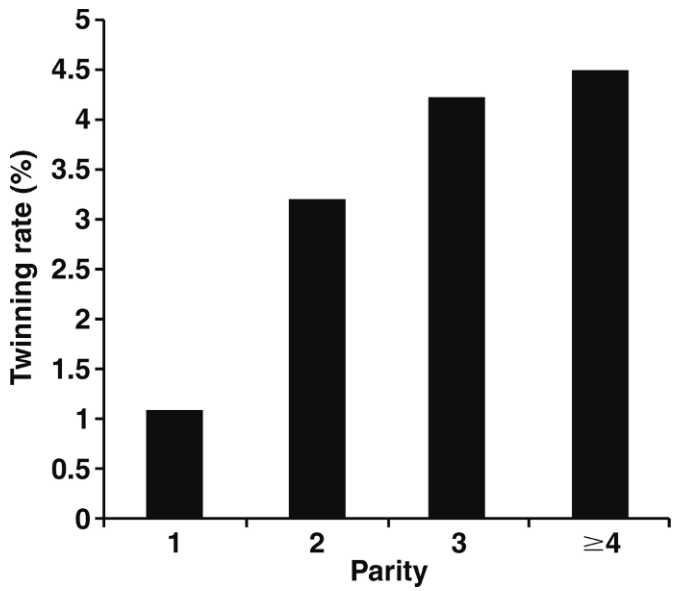

Figure 1. Twinning rate by parity for total data set. The frequency of twinning increased from 1.10% in parity 1 to 4.50% in parity 4 and greater.