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Improving the reliability of female fertility breeding values using type and milk yield traits that predict energy status in Australian Holstein cattle

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ABSTRACT

The objectives of this study were (1) to propose changing the selection criteria trait for evaluating fertility in Australia from calving interval to conception rate at d 42 after the beginning of the mating season and (2) to use type traits as early fertility predictors, to increase the reliability of estimated breeding values for fertility. The breeding goal in Australia is conception within 6 wk of the start of the mating season. Currently, the Australian model to predict fertility breeding values (expressed as a linear transformation of calving interval) is a multitrait model that includes calving interval (CVI), lactation length (LL), calving to first service (CFS), first nonreturn rate (FNRR), and conception rate. However, CVI has a lower genetic correlation with the breeding goal (conception within 6 wk of the start of the mating season) than conception rate. Milk yield, type, and fertility data from 164,318 cow sired by 4,766 bulls were used. Principal component analysis and genetic correlation estimates between type and fertility traits were used to select type traits that could subsequently be used in a multitrait analysis. Angularity, foot angle, and pin set were chosen as type traits to include in an index with the traits that are included in the multitrait fertility model: CVI, LL, CFS, FNRR, and conception rate at d 42 (CR42). An index with these 8 traits is expected to achieve an average bull first proof reliability of 0.60 on the breeding objective (conception within 6 wk of the start of the mating season) compared with reliabilities of 0.39 and 0.45 for CR42 only or the current 5-trait Australian model. Subsequently, we used the first eigenvector of a principal component analysis with udder texture, bone quality, angularity, and body condition score to calculate an energy status indicator trait. The inclusion of the energy status indicator trait composite in a multitrait index with CVI, LL, CFS, FNRR, and CR42 achieved a 12-point increase in fertility breeding value reliability (i.e., increased by 30%; up to 0.72 points of reliability), whereas a lower increase in reliability (4 points, i.e., increased by 10%) was obtained by including angularity, foot angle, and pin set in the index. In situations when a limited number of daughters have been phenotyped for CR42, including type data for sires increased reliabilities compared with when type data were omitted. However, sires with more than 80 daughters with CR42 records achieved reliability estimates close to 80% on average, and there did not appear to be a benefit from having daughters with type records. The cost of phenotyping to obtain such reliabilities (assuming a cost of AU$14 per cow with type data and AU$5 per cow with pregnancy diagnosed) is lower if more pregnancy data are collected in preference to type data. That is, efforts to increase the reliability of fertility EBV are most cost effective when directed at obtaining a larger number of pregnancy tests.

Key words: fertility, energy balance, type trait, selection index

INTRODUCTION

In recent decades, dairy cow fertility has been considered to be among the most important traits other than milk production (Bascom and Young, 1998; Groen et al., 1998). Female fertility is particularly important in countries that strive to match pasture growth to milk production. The extension of lactation by delaying pregnancy is not desirable in seasonal systems and entails a substantial economic loss (Bell et al., 2013). Nonetheless, no clear consensus exists as to which fertility traits must be included in selection indexes. Fertility is a complex trait with no single trait adequately describing it. Consequently, several measures of fertility are used to account for different aspects of the female

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reproductive cycle, such as showing estrus early in lactation, becoming pregnant in a timely way, and the ability to carry a pregnancy successfully to full term (Groen et al., 1998). Furthermore, every trait poses pros and cons in their use for genetic evaluations, such as censoring and skewed or discrete distributions, and are mostly management dependent (Oseni et al., 2004; González-Recio et al., 2004, 2005, 2006).

Australia implemented a multitrait model for genetic evaluation of fertility that encompasses onset of estrus, becoming pregnant, and carrying a pregnancy to term. The model includes calving interval (**CVI**) as a primary trait, lactation length (**LL**), days from calving to first service (**CFS**), first nonreturn rate (**FNRR**), and conception rate as correlated traits (Haile-Mariam et al., 2013). Although the fertility breeding goal in Australia is conception within 6 wk of the start of the mating season (**6WC**; Morton, 2004), CVI has been used as the main fertility trait because of lack of pregnancy records in the majority of herds. A linear transformation converts the CVI EBV from the multitrait model to a trait that approximates 6WC and assumes that the correlation between these traits is one. Recent studies have shown that the genetic correlation between these traits is less than one (Haile-Mariam et al., 2013). Therefore, a trait that uses information from multiple data sources may have a higher correlation with 6WC.

Data on 6WC is difficult to obtain on all cows without routine and extensive pregnancy testing. However, it is possible to calculate a trait that is close to 6WC using data from a variety of sources. Here, we define a trait, called CR42, which is defined as the probability of calving after being mated within a period of time that is 42 d (length of 2 normal reproductive cycles) from the beginning of the mating period. Trait CR42 is derived from pregnancy status, interval from calving to first mating, and calving interval data, and replaces pregnancy rate in the current index. Furthermore, CR42 becomes the main trait to be evaluated, instead of CVI. The CR42 is thought to be closer than CVI to the Australian fertility breeding goal, 6WC. Around 50% of herds in the Australian dairy industry follow a seasonal system, and it is therefore important to ensure that cows get pregnant within 6 wk (2 reproductive cycles) after the mating season begins. This is also valid for year-round calving systems, where the breeding goal may be viewed as getting pregnant within 2 cycles after first fertile estrus. Considerable efforts have been made over the last decade to collect more mating and pregnancy data for genetic evaluation purposes; it is therefore relevant to assess whether the main fertility trait can be changed from CVI to a trait closer to the breeding goal.

We considered a second strategy to increase the rate of genetic gain in fertility, which was including type and yield traits as early indicators of female fertility. Type traits have previously been found to be associated with female fertility. For instance, Pérez-Cabal et al. (2006) reported that impaired fertility was associated with poor scores for foot and legs traits. Type traits associated with energy balance, such as angularity or BCS, have been already shown to be genetically correlated with fertility traits (Pryce et al., 2000). Adding an indicator of energy status at a particular time during lactation could therefore improve the accuracy of prediction of female fertility.

The objectives of this study were to (1) test whether replacing CVI with CR42 as the primary selection criteria increased the correlation between the selection index and the breeding goal, and (2) to investigate whether the addition of type and yield traits in a combined energy status–fertility multitrait model increased the reliability of the CR42 EBV.

MATERIALS AND METHODS

Data

Two main data sets of first-parity Holstein-Friesian cows were used to estimate genetic parameters. The first data set comprised reproductive and milk yield traits, and the second data set included type traits on a subset of cows with reproductive data.

The traits analyzed were CVI, LL, CFS, FNRR, CR42, age at first calving (**AFC**), trait deviations for milk yield (305-d milk, fat, and protein yield), SCS, and 12 type traits: overall type, udder texture (**UDTEX**), bone quality (**BNE**), angularity (**ANGUL**), muzzle width (**MUZW**), pin width (**PNW**), pin set, mammary system (**MAMM**), body depth (**BD**), foot angle (**FA**), udder depth, and BCS. All the data used for this study were extracted from the Australian Dairy Herd Improvement Scheme (**ADHIS**) database. A detailed description of the data used for this study is given by Haile-Mariam et al. (2014). Briefly, data from herds with at least 100 calving records between January 1999 and December 2010 were selected. Bulls used in AI programs with at least 5 daughters were included in this study. Additionally, the study was restricted to first-parity cows that calved between 18 and 38 mo of age. To be valid, CVI had to have a minimum length of 290 d; CVI between 500 and 762 d were set at a maximum of 501 d to minimize the influence of extremely long intervals on both the variance and mean. In addition, cows that were recorded as culled for fertility in the ADHIS database were assigned a value for CVI that