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# Novel approaches to genetic analysis of fertility traits in New Zealand dairy cattle

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## ABSTRACT

The fertility of dairy cattle in New Zealand is well below industry targets, and the current New Zealand fertility breeding value (BV) could potentially be improved using additional information and traits. Data from 169 herds were analyzed to determine the benefits of using alternative phenotypic measures in the calculation of the fertility BV. The heritability of calving season day (CSD; calving season day as an integer day of the year) and the probability of an animal calving within 42 d of the planned start of calving (CR42) increased modestly (from 0.0206 to 0.0213 and 0.0087 to 0.0092, respectively) after accounting for the use of intravaginal progesterone-releasing devices for treatment of anestrous cows (anestrum treatment) and induced calvings. Incidence of either anestrum treatment or calving induction as a single binomial trait (AT/IND) had a heritability of 0.0223 and showed moderate genetic correlation with the probability of an animal being mated within 21 d of the planned start of mating (PM21; −0.4473), but much higher with CSD (0.8445). The use of pregnancy-diagnosis data allowed fertility information that would otherwise be discarded to be included in analyses; when used to assign a prolonged CSD and a value of 0 for CR42 to animals that failed to calve, it increased the heritabilities of both of these traits (to 0.0278 and 0.0114, respectively). Because CSD was found to be more than twice as heritable as its binary counterpart, it shows potential to replace CR42 as the calving trait used in the fertility BV. Postpartum anestrous interval (PPAI), derived using incomplete premating estrous recording in some herds, had a heritability of 0.0813 and hence has potential as a trait to be included in genetic improvement programs but would require more rigorous recording of estrous during the premating period to be an effective trait. Based on selection index theory, the modifications made to current selection criteria using novel fertility traits increased the accuracy of prediction of fertility merit by more than 12%. Because of the increasing economic importance of fertility traits, and low heritabilities requiring large numbers of recorded daughters to get accurate fertility BV predictions on sires, data recorded on farm will become increasingly important in the genetic improvement of fertility.
**Key words:** fertility, heritability, genetic evaluation, dairy cattle

## INTRODUCTION

In seasonal-calving dairy herds, which represent more than 90% of herds in New Zealand, a condensed calving pattern of no more than 12 wk in length is required to maximize the efficiency of a low-cost, spring pasture–based grazing system (Blackwell et al., 2010). This requirement constrains the seasonal breeding period to a similar length of around 12 wk. The indicators used in the industry definition of overall herd reproductive performance are the 6-wk in-calf rate (i.e., percentage of the lactating herd that become pregnant within the first 6 wk of the breeding period) and the empty rate (i.e., the percentage that fail to become pregnant during the breeding period). The respective industry targets are 78 and 6% for a 12-wk breeding period. In practice, however, the current average 6-wk in-calf rate is about 66% (Anonymous, 2014; Brownlie et al., 2014).

Although managerial factors significantly affect the level of reproductive performance achieved within a dairy herd, genetic fertility does have significant potential for improving herd reproduction in spite of a lowly 0.05 heritability estimate (Kadarmideen et al., 2003; Wall et al., 2003; Tiezzi et al., 2012). The proviso is that the high levels of environmental variation and recording errors associated with fertility traits can be minimized (Harris and Montgomerie, 2001; Harris et al., 2002). Usually, fertility measures can be expressed in 2 main categories: fertility scores represented by success rates, and interval traits measured in days (Pryce et al., 2004; Cammack et al., 2009). Most interval traits, such as days to first service, calving interval, and days open, are likely to be influenced more by management

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decisions and nutrition linked with energy balance during early lactation (Pryce et al., 2004) than fertility-score traits. Several fertility traits, such as age at first service, nonreturn rate, calving to first insemination, calving interval, and pregnancy rate within 21 d, have been analyzed and included in the selection indexes in different countries (e.g., VanRaden et al., 2002; VanDoormaal et al., 2004; VanRaden et al., 2004). However, interval traits tend to be unsuitable for genetic evaluation of fertility in seasonal dairy systems where animals that calve early are withheld from being bred until the seasonal breeding period begins (Blackwell et al., 2010).

Fertility was first added as a breeding value (**BV**) to the New Zealand economic selection index, Breeding Worth, in 2001 (Harris and Montgomerie, 2001), with the proportion of calvings within 42 d of the planned start of calving (**CR42**) included in the national breeding goal. This and the proportion of cows mated in the first 21 d from the planned start of mating (**PM21**) for the first 3 lactations are the primary direct selection criteria used for prediction of the breeding goal, although milk yield and BCS are also used as correlated predictor traits (Harris et al., 2006). These traits indirectly measure the genetic propensity of a cow to return to a fertile state after calving and to become pregnant in a timeframe that will allow it to maintain a 365-d calving interval (Burke and Verkerk, 2010). Although evidence exists that maiden heifer fertility traits are genetically correlated with mature cow traits (Pryce et al., 2007), no traits derived from the first calving date are currently used in the genetic evaluation of fertility in New Zealand.

Maintaining a seasonal-calving herd is, however, commonly achieved with some dependence on hormonal interventions. For example, in a prospective survey of 72,006 cow lactations in New Zealand herds, Brownlie et al. (2014) reported that 5.7% of these were initiated with a hormonally induced calving and that breeding was assisted with a hormonal noncycling treatment in 8.9% of these lactations. The use of fertility data in genetic evaluations from animals that have been treated to mitigate for poor fertility may lead to distortion of heritabilities and of accuracy of various fertility traits. In addition, there is potential to use pregnancy-confirmation data to incorporate an interval-type trait for further refining the true measure of genetic fertility. Novel criteria for measuring, recording, and accounting for these influences on fertility may improve the genetic selection strategies and have a meaningful effect on the accuracy of predictions of genetic merit of fertility in sires.

Accordingly, we hypothesized here that the accuracy of the fertility trait estimated BV would be improved when data were censored for quality to minimize the effect of management interventions on the genetic evaluation. Additionally, we investigated the relationships between national fertility evaluation BV traits (CR42 and PM21) and additional fertility traits in cows and heifers. The specific objectives were to assess how new approaches to genetic analysis of fertility traits may improve the accuracy of prediction of fertility in the national breeding objective, including (1) determining the influence of intravaginal progesterone-releasing devices for treatment of anestrum (anestrum treatment) and calving induction, as well as data modifications based on pregnancy diagnosis on efficacy of fertility records; (2) determining the effect of modifying binomial traits to continuous traits; and (3) investigating the correlation of maiden heifer fertility traits with mature cow fertility traits.

## MATERIALS AND METHODS

### *Fertility Traits*

The fertility parameters investigated in this study were postpartum anestrous interval (**PPAI**), the probability of PM21 as a binary trait, mating season day (**MSD**) as an integer day of the year, the probability of CR42 as a binary trait, calving season day for cows (**CSD**) and for heifers (**HCSD**) both as an integer day of the year, and a binomial trait representing the incidence of anestrum treatment or calving induction (**AT/IND**). Defining MSD, CSD, and HCSD as respective integer days of the year is identical to defining these traits as the number of days from the relevant planned start of mating or calving but has the advantage of not requiring any definition of planned start of mating or calving. This is because differences between contemporary groups in planned start of mating and calving are accounted for in the contemporary group solutions fitted in the statistical models. Because of the fact that New Zealand dairy herds have a fixed start of mating date for all cows, and a separate date for heifers, the continuous mating and calving traits (i.e., MSD, HCSD, and CSD) reflect more variability in the earliness at which cows are mated and calved in the phenotype under analysis. However, much of this variability can be attributed to the completely random nature of where a cow sits in its estrous cycle at the beginning of the mating season, the day of which is determined by management at the herd level.

A minimum of 50 cows or heifers per herd in a year was required for data inclusion. Postpartum anestrous interval was defined for all cows as the number of days from the previous parturition to the first observed estrous (or at first mating if a premating estrous was not