J. Dairy Sci. 101:1–10
https://doi.org/10.3168/jds.2017-13538

Mating strategies to maximize genetic merit in dairy cattle herds

T. Johnson,* K. Eketone,* L. McNaughton,* K. Tiplady,* J. Voogt,† R. Sherlock,* G. Anderson,* M. Keehan,* S. R. Davis,* R. J. Spelman,* D. Chin,‡ and C. Couldrey*[1]
*Research and Development,
†Emerging Markets and Innovation, and
‡Transformation Office, Livestock Improvement Corporation, Hamilton, New Zealand 3286

ABSTRACT

The genetic merit of a herd is a key determinant in productivity for dairy farmers. However, making breeding decisions to maximize the rate of genetic gain can be complex because there is no certainty about which cows will become pregnant with a heifer calf. In this study, breeding worth (BrW) was used as a measure of genetic merit, and several mating strategies were evaluated. These strategies included randomly mating whole herds to the entire bull team, excluding low-ranked cows from producing replacement heifers, and nominating high-ranked cows to the most highly ranked bulls. Simulations were undertaken using 4 bull teams generated from bulls currently marketed in New Zealand and a selection of New Zealand dairy herds. Average replacement heifer BrW was calculated for 1,000 iterations of each combination of mating strategy, herd, and bull team (scenario). Variation in resulting average replacement heifer BrW within scenarios was due to random sampling of which cows became pregnant with a heifer calf. Relative to mating the whole herd to an entire bull team, excluding the lowest ranked cows from producing replacements resulted in the greatest increase in average replacement heifer BrW across all herds and bull teams, with a gain of approximately 0.4 BrW point for each 1% of cows excluded. Nominating top-ranking cows to the highest ranking bulls in the team had little effect (0.06–0.13 BrW increase for each 1% of top cows nominated) in improving BrW of replacement heifers. The number of top bulls nominated had a variable effect depending on the BrW spread of the entire bull team. Although excluding cows with the lowest BrW from producing replacement heifers is most effective for improving BrW, it is important to ensure that the number of heifers born is sufficient to replace cows leaving the herd. It is likely that optimal strategies for improving BrW will vary from farm to farm depending not only on the BrW structure of the herd, the bull team available, and the reproduction success on farm but also on farm management practices. This simulation study provides expected outcomes from a variety of mating strategies to allow informed decision making on farm.
Key words: dairy cattle, breeding worth, genetic improvement

INTRODUCTION

Dairy farming contributes approximately 37% of the total value that New Zealand earns from export (DairyNZ, 2014b). Although the returns for milk adjusted for inflation have declined in the last 20 yr, selective breeding for genetic improvement has allowed economic efficiency to be maintained on New Zealand dairy farms (Harris et al., 2007). Given the current volatility in global dairy prices and the recent decline in numbers of dairy cattle in New Zealand (LIC and DairyNZ, 2016), genetic improvement remains a vital part of dairy farming. The success of selective breeding for genetic improvement in New Zealand dairy cattle is largely due to the national breeding objective "to breed dairy cows that are able to efficiently convert feed into profit." To rank cows and bulls according to their ability to meet the national breeding objective, an economic index known as breeding worth (**BrW**; Harris et al., 2007) has been developed. This across breeds genetic evaluation makes adjustments for the fact that multiple breeds of dairy cattle are milked in New Zealand (19.8% Holstein Friesian, 7.3% Jersey, 70.6% Holstein Friesian × Jersey, and 2.3% other breeds; Livestock Improvement Corporation internal database, Hamilton, New Zealand) and that the vast majority of herds contain genetics from multiple breeds (<2% of herds contain only a single breed; Livestock Improvement Corporation internal database). The BrW index is calculated by combining breeding values (genetic merit for individual traits) with estimated economic values (per dollar unit increase) of the trait to a New Zealand dairy farmer. The traits used in the BrW index

Received July 20, 2017.
Accepted January 1, 2018.
[1]Corresponding author: Christine.couldrey@lic.co.nz

are milk fat, protein, milk volume, live weight, fertility, SCC, BCS, and residual survival (DairyNZ, 2014a). Breeding worth is expressed as dollars of net farm income per 5 t of DM relative to a genetic base cow (currently the average of cows born in 2005; DairyNZ, 2014a). Currently, 1 genetic standard deviation equals 80 points. The BrW index is therefore able to compare animals across breeds. This allows farmers to easily rank animals in the herd for their genetic ability to breed replacements even if the herd consists of multiple breeds. Given that the BrW index is specifically designed to breed for genetic improvement in accordance with the national breeding objective, it does not aim to capture heterosis and currently does not capture dominance effects. In New Zealand, both heterosis and all other nonadditive effects are captured as production worth (DairyNZ, 2015).

Culling of cows based on their performance is one strategy for improving production efficiency. However, in terms of herd improvement, it is essential that young heifers entering the herd are genetically superior to the cows they are replacing. Although this may seem intuitive, making breeding decisions to maximize the genetic merit of the herd can be complex. Some of this complexity stems from the fact that it is not possible to know which cows will come into heat and be submitted for AI or which will become pregnant with a female calf. This complexity is of particular importance in the seasonal dairy farming systems common in New Zealand, where a calving interval of close to 365 d needs to be maintained (Holmes et al., 2002). In these seasonal systems, only cows becoming pregnant in the short AI period (typically 3–6 wk) are able to generate herd replacements.

Despite the complexities, there is much interest in maximizing genetic merit within dairy herds. A considerable number of studies have produced models to maximize genetic gain; however, these studies have either been undertaken in the context of bull breeding to produce the best bulls (Börner et al., 2012; Reiner-Benaim et al., 2017) or modeled the effectiveness of new reproductive technologies (e.g., embryo transfer) and the use of genomics (Calus et al., 2015; Thomasen et al., 2016). Currently, the use of new reproductive technologies is still very much in the minority in commercial dairy farms in New Zealand (<0.2% of calves born in New Zealand). Similarly, the use of genomics for female selection is very limited in New Zealand, largely due to the challenges faced in undertaking genomic prediction in a largely crossbred population. Given these practicalities, there is currently a lack of scientific data around different mating strategies that farmers can easily use on farm to maximize the genetic gain on offer from breeding companies while also taking into account their individual farming systems and breeding goals. Here we used BrW data from New Zealand herds and current bulls to simulate the effects of different mating strategies on replacement heifer BrW and ultimately identify the most efficient and maximal rate at which BrW may be improved. There are 2 distinct opportunities during which the average BrW of replacement heifers entering the herd may be influenced: (1) at mating to generate the replacements and (2) before the heifers enter the herd, when the best of those calves generated can be selected (assuming that sufficient calves have been generated by the mating strategy at the earlier opportunity). The data presented here examine the decisions made only at the time of mating, as this is the more complex of the two.

MATERIALS AND METHODS

Data

Herd Selection. Herds were selected from all New Zealand recorded herds with at least 100 cows (10,755 herds). Individual animal BrW were used to calculate the average BrW and standard deviation of BrW for each herd. The relationship between average herd BrW and the standard deviation of herd BrW, as well as average herd BrW relative to herd size, is shown in Figure 1. A subset of herds was selected as representative herds to be used in simulation studies. The first selection criteria were based on the average herd size in New Zealand being approximately 400 cows (LIC and DairyNZ, 2016); herds of 300 to 500 cows were therefore selected. Within this herd size, the distributions of average herd BrW and the standard deviation of herd BrW were used to define 5 groups of herds (Table 1): high BrW with low standard deviation (n = 18), average BrW with low standard deviation (n = 16), average BrW with high standard deviation (n = 4), low BrW with low standard deviation (n = 7), or low BrW with high standard deviation (n = 7). No herds with high BrW and high standard deviation were observed.

Bull Team Selection. Bull teams were generated from the current ranking of active sires (**RAS**) list March 28, 2017 (DairyNZ, 2017), based on their BrW and rank overall for a mixed-breed team or within breed for a breed-specific team. Reliability of BrW for each of the bulls was greater than 79%. Figure 2 shows the variation in the distribution of BrW for the 10 bulls in each of the 4 bull teams used. The mixed-breed team made up of the top 10 bulls on the RAS list (regardless of breed) had a very narrow spread of 13 BrW points with one exception, where the top bull had a BrW that was 42 points higher than that of the second highest bull. The team consisting of the top 10 Jersey bulls had