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The cost-benefit of genomic testing of heifers and using sexed semen in pasture-based dairy herds

J. E. Newton,[*1] **B. J. Hayes,**[*†] **and J. E. Pryce**[*‡]
*Agriculture Victoria, AgriBio, Centre for AgriBioscience, Bundoora, VIC 3083, Australia
†Queensland Alliance for Agriculture and Food Innovation, University of Queensland, Brisbane, St. Lucia, QLD 4072, Australia
‡School of Applied Systems Biology, La Trobe University, Bundoora, VIC 3083, Australia

ABSTRACT

Recent improvements in dairy cow fertility and female reproductive technologies offer an opportunity to apply greater selection pressure to females. This means there may be greater incentive to obtain genomic breeding values for females. We modeled the impact of changes to key parameters on the net benefit from genomic testing of heifer calves with and without usage of sexed semen. This paper builds on earlier cost-benefit studies but uses parameters relevant to pasture-based systems. A deterministic model was used to evaluate the effect on net benefit due to changes in (1) reproduction rate, (2) genomic test costs, (3) availability of parent-derived breeding values (EBV_{PA}), and (4) replacement rate. When the use of sexed semen was included, we also considered (1) the proportion of heifers and cows mated to sexed semen, (2) decreases in conception rate in inseminations with sexed semen, and (3) the marginal return for surplus heifers. Scenarios with lower replacement rates and no availability of EBV_{PA} had the largest net benefits. Under current Australian parameters, the net benefit of genomic testing realized over the lifetime of genotyped heifers is expected to range from A$204 to A$1,124 per 100 cows for a herd with median reproductive performance. The cost of a genomic test, a perceived barrier to many farmers, had only a small effect on net benefit. Genomic testing alone was always more profitable than using sexed semen and genomic testing together if the only benefit considered was increased genetic gain in heifer replacements. When other benefits (i.e., the higher sale price of a surplus heifer compared with a male calf) were considered, there were combinations of parameters where net benefit from using sexed semen and genomic testing was higher than the equivalent scenario with genomic testing only. Using sexed semen alongside genomic testing is most likely to be profitable when (1) used in heifers, (2) the marginal return for selling surplus heifers (sale price minus rearing costs) is greater than A$400, and (3) conception rates of no more than 10 percentage points lower than those achieved using conventional semen can be realized. Net benefit was highly dependent on the marginal return. Demonstrating that the initial investment in genomic testing can be recouped within the lifetime of the heifers tested may assist in the development of extension messages to explain the value of genomic testing females at the herd level.
Key words: genomic testing, rate of genetic gain, sexed semen

INTRODUCTION

The commercialization of genomic testing has irrevocably changed dairy cattle breeding schemes. The high reliabilities being achieved for EBV derived using genomics (**EBV_G**), coupled with reductions in the cost of genomic testing, have seen the number of animals evaluated using genomic data increase exponentially. For instance, at the beginning of 2009, shortly after genomic testing was first offered commercially in the United States, fewer than 20,000 animals had been tested. Today, over 211,000 Holstein bulls and over 1.2 million Holstein cows have been evaluated using genomics in the United States (https://www.uscdcb.com/Genotype/cur_density.html; accessed April 2017).

Genomic testing of commercial dairy females benefits genetic evaluations of populations through regular contributions to reference populations (Mc Hugh et al., 2011; Pryce et al., 2012). Herd-level benefits include (1) more reliable decisions in selecting herd replacements, (2) fewer errors in parentage assignment, (3) the development of more targeted breeding objectives, and (4) earlier identification of candidates to artificially inseminate (AI) to high-value semen or for use in embryo transfer and in vitro fertilization programs.

Relatively few studies consider the cost-benefit of genomic testing of commercial dairy heifers at a herd

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[1]Corresponding author: jo.newton@ecodev.vic.gov.au

level and many of these vary widely in their estimates of the benefits. For example, when considering the value of genomic testing over selection based on the average of parent EBV (**EBV_{PA}**), Pryce and Hayes (2012) concluded that at a cost of A$50 per test (Australian dollars), genomic testing of heifers could not be justified. However, Weigel et al. (2012) concluded that, in most instances, the benefits exceeded the costs of genomic testing whether EBV_{PA} were available or not. Both studies used the reliability of EBV_{PA} (**R_{PA}**) in their calculation of the benefit of selection using EBV_G over EBV_{PA}. This is calculated from sire and dam reliabilities (R_s and R_d) as follows: $R_{PA} = 0.25 \times (R_s + R_d)$. Bijma (2012) showed that, in selected populations, doing this leads to an overestimation of the genetic progress possible, because the reliability of selection based on EBV_{PA} is lower than the reliability of EBV_{PA}. When Calus et al. (2015) applied the correction suggested by Bijma (2012), they demonstrated that the benefits of selection using genomic-based strategies over pedigree-based selection strategies were likely to have been underestimated in earlier papers.

One of the challenges with genomic testing of female replacements is that there has been little room to apply selection pressure because most heifers are retained as replacements (Boichard et al., 2013). Recent indications are that selection for fertility is improving cow reproductive performance (Berry et al., 2014), meaning more replacements are being born. The use of sexed semen in AI programs also offers an opportunity to increase the number of heifer calves born and to intensify selection pressure on the female side (Boichard et al., 2013; Hjortø et al., 2015). Recent field trials show that sexed semen AI is starting to achieve conception rates more comparable to that of conventional AI (Healy et al., 2013; Butler et al., 2014; Izzo, 2015). Thus, using sexed semen in conjunction with genomic testing may be a profitable strategy.

Calus et al. (2015) found that the potential benefits from using EBV_G instead of EBV_{PA} were greater when sexed semen was used. However, they did not include the additional costs associated with using sexed semen (i.e., higher cost of straws and the cost of rearing additional heifer calves). In assessing the value of sexed semen, Fetrow et al. (2007) included many of these but did not put a value on genetic gain. They concluded that using sexed semen is unlikely to be cost effective unless genetic gain is considered. Although McCullock et al. (2013) included a genetic gain variable alongside other costs, the interaction between increased number of selection candidates (due to increased sexed semen usage) and genetic gain was not considered.

The net benefit from genomic testing is largely governed by the intensity with which selection can be applied. At the herd level, this is influenced by parameters such as reproduction rate in heifers and cows and herd replacement rate. It is possible that the cost-benefit of genomic testing is different in pasture-based herds compared with confined systems reliant on TMR. For example, the number of calves born to AI sires versus non-AI herd bulls is a consideration in pasture-based herds. This is because for most pasture-based systems, it is general practice to have a defined period of mating to AI bulls followed by non-AI herd bulls.

The broad aim of this study was to evaluate the effect of changes to key herd parameters on the net benefit from genotyping heifers to inform selection decisions. We also evaluated whether the net benefit of genomic testing increased by concurrently adopting sexed semen with genomic selection. We build on earlier studies on the adoption of genomic testing either alone or in conjunction with sexed semen. In addition to using the formula of Bijma (2012) and accounting for discounting over time, we included parameters associated with reproduction rate as a simulation input. Using this instead of number of calves meant the effect of reduced conception rates associated with sexed semen could also be included.

MATERIALS AND METHODS

Overview

A deterministic simulation tool was developed in R version 3.2.3 (R Development Core Team, 2017) to estimate the net benefit from genotyping heifer selection candidates in commercial dairy herds. In total, 3 scenarios were considered, as described in Table 1. In brief, in scenario 1, only the adoption of genomic testing was considered. Scenarios 2 and 3 included the concurrent adoption of sexed semen to increase the number of heifer selection candidates alongside genomic testing. In scenario 2, only the cost of genomic testing and the additional cost of purchasing sexed semen were considered in the model. In scenario 3, the cost of genomic testing plus additional costs, losses, and benefits likely to be associated with the adoption of sexed semen were considered. All results are reported in Australian dollars (**A$**); A$1 = US$0.80 (http://www.xe.com/currencyconverter/; accessed January 2018).

In the first scenario, we varied (1) reproduction rates, (2) genomic test costs, (3) availability of EBV_{PA}, and (4) replacement rates. Ranges and levels for each parameter varied are given in Table 2. In the sexed semen scenarios (scenarios 2 and 3), the additional parameters that were varied were (1) the proportion of heifers or cows bred to sexed semen, and (2) the decrease in conception rate in inseminations with sexed semen. In