The Use of Genetic Selection to Improve Herd Reproductive Performance of Dairy Cattle in Northern Victoria, Australia: Preliminary Results

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Abstract

With any new management tool, managers of dairy herds can be slow to adopt changes until they are aware that the practice exists, have the skills to implement it, and are confident that it has beneficial effects on herd profitability. Accordingly, there is a need to validate the use of the Daughter Fertility Australian Breeding Values (ABVs) in order to better demonstrate its value. There is also a need to describe farmer usage and attitudes towards the Daughter Fertility ABV in order to identify barriers and improve uptake of the technology.

With this in mind, a validation study was undertaken in two parts. The first part comprised a retrospective cohort study, using reproductive event information and pregnancy testing data collected from 35 dairy herds that were clients of the Rochester Veterinary Practice. Survival analyses (with the eventual plan to perform a multiple linear regression) was undertaken to quantify the association between Daughter Fertility ABV and phenotypic expressions of cow fertility. These included Australian industry standards such as the 6-week in-calf rate, 3-week submission rate and conception rate.

The second part of this study documented herd manager attitudes and intentions towards genetic selection for daughter fertility, using the Theory of Planned Behavior as a social research framework. A total of 33 herd managers were interviewed about their salient beliefs, social norms and perceived barriers regarding the selection of high daughter fertility ABV sires. These results were then used to test the strength and prevalence of these beliefs amongst the wider population of Rochester Veterinary Practice clients (n = 168) using a postal survey. Regression will be used to identify key beliefs and herd manager characteristics that contribute to selection and intention to select high daughter fertility ABV sires.

This paper provides preliminary results of the data collected for this study, as presented at the Interbull Meeting in 2018.

Key words: fertility, dairy cows, genetic selection, breeding value, reproductive performance

Introduction

In 1979/80 the average annual milk volume yield per cow in Victoria was 3,012 litres (10 litres per day for a 300-day lactation). This has risen to 5,808 litres in 2014/15 (19.4 litres per day for a 300-day lactation), representing almost double the amount of milk per cow produced in the last thirty years (Dairy Australia, 2018).

It is evident that breeding for a single trait (high production) in dairy cows has been responsible for rapid improvements in this area.

However, the downside of single-trait breeding is the compensatory devolution of other traits. In this case, dairy fertility has seen a significant decrease over a similar time period and an unfavorable genetic correlation has been shown to exist between milk yield and fertility (Pryce & Veerkamp, 2001).

The consequences of poor fertility in dairy herds are severe. Dairy cows must reproduce to 1) continue producing milk and 2) replace culled members of the herd. Pregnancy and parturition are in reality essential components of efficient dairy production. Cows that are unable to produce milk leave the herd prematurely, which results in a poor return on the considerable investment of time and money that goes into preparing herd replacements. Infertility, along with mastitis, is one of the most common reasons for involuntary culling in Australian herds (Stevenson & Lean, 1998).

In order to halt the decline in reproductive performance, an Australian Breeding Value for daughter fertility was first released in 2003 to allow farmers to differentially select bulls with higher than average daughter fertility. This ABV was then further refined in 2013, improving the reliability of the ABV using a multi-trait model (Pryce *et al.,* 2013).

Attitudes towards genetic selection and breeding preferences were analyzed extensively prior to the triple index change in 2015 in order to create a new system which best suited Australian herd managers (Byrne *et al.,* 2015). However, there have been few studies that have looked into the attitude of farmers towards genetic selection for a single trait (in this case, daughter fertility).

The InCalf Project identified several key management areas that farmers could use to improve herd reproductive performance. Although these management areas are important, the use of genetic gain to improve fertility is an essential intervention for progress. Genetic gain is both sustainable and cumulative, with improvements in one generation passing onto the next. There stands to be significant benefit for the industry in increasing the use of the daughter fertility ABV by herd managers seeking to improve herd reproductive performance.

However, the release of a new tool or technology – no matter how effective it is – is not the end step for improving agricultural productivity. Extension is essential to seeing practice change on farms and the widespread adoption of helpful technologies. Technology adoption in the genetic selection area is especially complicated for several reasons.

Firstly, the market for genetic material is very competitive. Often sellers use international sires described using non-Australian estimates of merit, particularly if their top sires are no longer highly ranked when using Australian selection indices. The science can be complex and difficult to understand, and is dominated by numbers and acronyms. The number of bulls available for purchase, especially with the introduction of genomic selection, is large and the amount of spare time that herd managers possess to effectively assimilate this information is often limited. This can lead to an environment where herd manager confidence in their own decision-making abilities and awareness of available tools and resources is low.

Trust is also a key factor which determines whether herd managers are likely to adopt new practices or changes in management. People are naturally less likely to trust methods and concepts which they do not understand, and to feel suspicious when receiving unsolicited advice from external authorities – even when it is for their own benefit.

These complications make genetic selection an interesting topic for study – due both to the availability of high volumes of data, and the chance to learn more about herd manager behavior and decision-making processes. It also represents an opportunity to improve herd manager awareness and understanding of the genetic improvement of herd fertility, thereby addressing some of the barriers to adoption described above.

Research Aims

To describe the relationship between the daughter fertility ABV and phenotypic expressions of individual cow reproductive performance.

To describe herd manager attitudes towards genetic selection for fertility, and to identify barriers to selection for high daughter fertility.

Materials and Methods

Part 1: Daughter fertility ABV analysis

The first part of the project was a retrospective cohort study using data collected from 35 dairy herds who are clients of Rochester Veterinary Practice in northern Victoria, Australia. These herds were purposively selected on the basis of being known to be good record-keepers, use of herd testing, and routine use of early rectal pregnancy testing.

Table 1. Summary of data collected.

	Data collected
Herd level	37 herds Farm demographic data
Cow level	83 932 cows (birthdates ranging from 1965 – 2017) 31 083 Holstein-Friesians 6327 Jerseys
Lactation level	214 406 calving records 423 934 mating and pregnancy test records 902 015 herd test records

The majority of herd records were extracted from herd software systems. Some farms contributed data via their herd test centres. Two sets of herd records were entered manually from wall charts and artificial insemination books.

All .103, .108, .102 and .104 DIF files were exported from herd records into a relational database using automated scripts to minimize transcription errors. Base level data manipulation was then performed using structured query language queries. Once prepared, tables were imported into the statistical package R using the contributed RODBC statistical package.

Daughter fertility ABV determination

Once collected, the estimated Daughter Fertility ABV (ABV_{DF}) of each cow was calculated using Sire Daughter Fertility ABV (ABV_{SDF}) and Dam Sire Daughter Fertility (ABV_{DSDF}):

$$ABV_{DF} = [0.5 \times ABV_{SDF}] + [0.25 \times ABV_{DSDF}] + 0.25 \times 100$$

Each cow's genetic makeup is composed of half of her sire's genome plus half of her dam's genome. In this case, however, the dam ABVs are largely unknown, so the maternal grandsire's daughter fertility ABV value is used as a proxy (as he contributes a half to his daughter's genome and a quarter to his granddaughter's genome). The remaining 25% of her genetic contribution was set as if her dam was 100 for daughter fertility (the breed average). In this way, the estimated cow daughter fertility ABV is based on the known daughter fertility ABVs of her male pedigree.

Mating start date determination

Mating start dates (MSDs) were determined for each mating period within each herd.

Heifers in the Rochester Veterinary Practice district are likely to undergo separate joining programs compared to mature cows. They are often mated several weeks earlier than multiparous cows and enrolled in synchronization programs using fixed time artificial insemination, which introduces a significant amount of noise into standardized measures of herd performance. For this reason, services for animals without a previous recorded calving event were excluded.

Only services with Australian Dairy Herd Improvement Scheme (ADHIS) mating codes 0 to 7 were included.

The statistical package R was used to create a series of *for* loop algorithms identifying potential MSDs for each herd for each year according to the following criteria:

1. A true MSD must be the first of two consecutive days with mating events
2. At least three of the next six days must also have mating events
3. There must be a period of at least 50 days between two true MSDs.

MSDs were defined in the InCalf Project using the first and second criteria listed above (Morton, 2011). However, the third criterion used (that a MSD is defined by the first date with services following a period of 30 or more days with no services) was rejected for this project, as a large number of herds had scattered single insemination dates that did not fit into a defined mating period.

Instead, frequency histograms of mating events were constructed for each herd and the candidate MSDs generated by the algorithm superimposed on each plot. MSDs likely to represent fixed time artificial insemination events (with high numbers of inseminations relative to herd size and very few inseminations in the days following) were excluded, as were MSDs with few recorded inseminations. Potential MSDs that were preceded by single days where two or more inseminations were recorded were adjusted to include these events. Out of 792 potential MSDs identified by the algorithm, 39 required manual adjustments and 100 were excluded – leaving a total of 692 mating periods in the dataset.

Each MSD was then defined as either ‘split’ or ‘seasonal’ depending upon how many mating periods were recorded for that herd for a given year. If only a single MSD was recorded, it was considered ‘seasonal’ regardless of the time of year it occurred in. Historically, most herds in the dataset began with seasonal MSDs before changing to a split calving system, with a transition period where some years are split and others are seasonal. A total of 173 of the 692 mating periods were classified as ‘seasonal’ in total, with only two herds with ‘seasonal’ MSDs in 2016.

3-week submission rate analysis

Once mating periods were defined, 3-week submission rates were calculated for each cow for each mating period that she was eligible to be joined in. A cow was considered to have been submitted in the first three weeks of mating if she had a recorded mating event within 21 days after MSD.

A cow was considered eligible to be joined if she had a recorded calving date within 120 days before MSD for split calving herds, or 130 days before MSD to 59 days after MSD for seasonal MSDs. These cut-off points reflect those chosen for the generation of Fertility Focus Reports, which are the industry standard for measurement of herd reproductive performance.

Cows with a termination date between calving and MSD were removed from the data set. Cows with termination dates after MSD were retained, as these would be accounted for using Kaplan-Meier survival analyses. The resulting dataset comprised 133,311 mating events.

Kaplan-Meier survival curves were generated using the R survival package (Therneau & Grambsch, 2000). Frequency histograms of daughter fertility ABVs represented by Holstein Friesians and Jerseys were generated, showing that ABVs were distributed normally. Cows were then divided into breeds and split further into ABV quartiles. Kaplan-Meier survival curves were generated for showing the interval from MSD to first service for each breed, stratified by ABV quartile.

The next step will be to quantify 3-week submission rates, adjusting for the potentially confounding effects of cow age, the number of days calved at MSD, age, milk protein percentage, herd and year using Cox proportional hazards regression.

Part 2: Farmer attitudes, intentions and behaviors

The Theory of Planned Behavior is a social research framework used to explore and predict human behavior (Armitage & Conner, 2001). The theory is that human behavior is shaped by personal beliefs, social norms, and perceived barriers.

The framework has been used to predict behavioral intention in a wide variety of fields, such as advertising, social work and health promotion. In health, it has been used to understand why people undertake risky behaviors that are counterproductive to a healthy lifestyle (e.g. overeating, smoking, etc.) or do not adopt behaviors that promote good health (e.g. exercise). In agriculture, it has been used to explore why farmers do not take up new technologies or management practices that would seemingly contribute to improved productivity and/or profitability (Garforth *et al.*, 2006).

Elicitation study

In order to ensure that beliefs to be tested were correctly identified, an elicitation study was performed.

A total of 33 farmers were interviewed, with a total of 7 hours and 47 minutes recorded. Herd managers for this study were the same as those that contributed data for the ABV analyses, with two herd managers electing not to take part due to time constraints.

Each herd manager was asked to complete a demographic survey to supplement data collected in the interviews. The recordings were then transcribed and key beliefs identified. A belief was considered 'salient' if it was mentioned by more than one individual.

Human ethics was sought and approved by the University of Melbourne Faculty of Veterinary Science (reference number 1647167.2).

Postal survey

A three part questionnaire was created from this information, with the first part made up of demographic questions, the second part consisting of indirect and direct measures of salient beliefs, social normal and perceived barriers, and the third part asking for a list of bulls that were used in the previous joining period along with the number of straws purchased. Questions testing the *relevance* of beliefs had answers ranging from 'strongly disagree' to 'strongly agree' on a 1 to 7 Likert scale. Questions testing *outcome* beliefs were on an ordinal scale from -3 to +3 from 'extremely undesirable' to 'extremely desirable'.

The questionnaire was sent to 168 dairy clients at Rochester Veterinary Practice along with a cover letter explaining the project, a plain language statement and a consent form to be signed and returned. Those that had email addresses were sent a link to the electronic version. The survey was also advertised in the clinic newsletter. Veterinarians were asked to follow surveys up with clients during farm visits, and reception staff were asked to remind clients coming in to pay their bills. A follow up letter was sent two months after the first survey was released.

In total, there were 40 replies, which is a response rate of 23.8% - not an unusual result for surveys of this kind (Garforth *et al.*, 2006).

Analysis

Questionnaire responses were coded and entered into a relational database for further manipulation. In total, 358 bulls were listed as having being purchased by survey respondents for the specified joining periods.

The next step will be to calculate the average weighted daughter fertility ABV of bull teams used by respondents and then correlate their various demographic characteristics and beliefs with this value.

Results & Discussion

Daughter fertility ABV analysis

ABV trend analysis

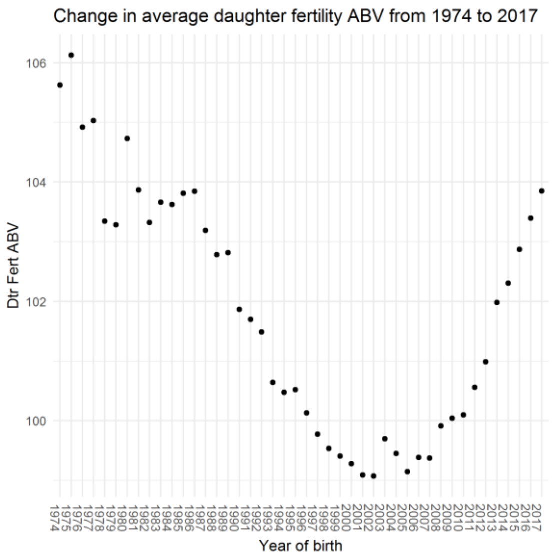

Figure 1. Change in average daughter fertility ABV for cows born over the last 43 years, from 1974 to 2017.

Figure 1 reflects the change in cow fertility over time – showing a strong decline from 1974 until reaching a plateau in the early 2000's.

The first iteration of the daughter fertility ABV was released in 2003, and the most recent multi-trait ABV was released in 2013. There has been a steep rise in fertility since the ABV was created, with cows born in recent years possessing ABVs equivalent to cows born in the early 1980's.

ABVs change over time. These cow daughter fertility ABVs are based on the December 2016 release and the intent of this graph is to show change in trends over time, not to demonstrate absolute measures of phenotypic performance.

3-week submission rates

The analyses describing the time to submission stratified by ABV category have not been adjusted to account for potential confounders and should be interpreted as preliminary findings only.

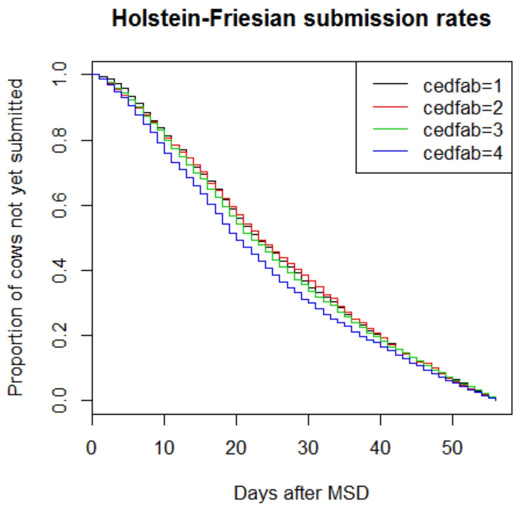

Figure 2. Kaplan-Meier survival curves showing the difference in submission rates between quartiles of daughter fertility ABV for Holstein-Friesians, with cedfab=1 representing the lowest 25% of cows and cedfab=4 representing the top 25%.

The median number of days to submission for the top 25% of daughter fertility ABV Holstein-Friesian cows was 21 days, compared to 24 days for the bottom 25% of cows.

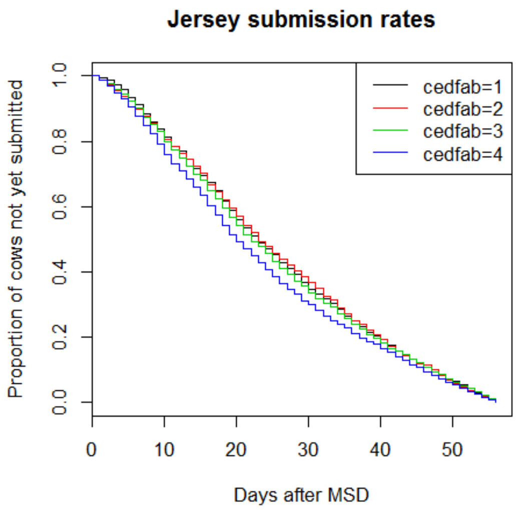

Figure 3. Kaplan-Meier survival curves showing the difference in submission rates between quartiles of daughter fertility ABV for Jerseys, with cedfab=1 representing the lowest 25% of cows and cedfab=4 representing the top 25%.

The median number of days to submission for the top 25% of daughter fertility ABV Jersey cows was 20 days, compared to 23 days for the bottom 25% of cows.

Farmer attitudes, intentions and behaviors

Elicitation study

The elicitation study provided a rich base of qualitative data, including quotes from farmers that illustrate the complicated nature of genetic extension. Two of them were as follows:

(1) 'I'm not really into the technical side of it that much, so I'm not sure how they're coming up with the daughter fertility of these bulls. All the time the bull companies are sending out these catalogues and they've got something to sell and they'll use any trick they can to get you to buy a bull.'

(2) 'Hopefully it's all above board and they're doing the right thing, but the other possibility is that it's just a sales gimmick! Hopefully that's not the case but you can't be sure.'

The following three tables show the most common beliefs identified in face-to-face interviews with 33 farmers.

Table 2. Farmer attitudes toward selection of high daughter fertility ABV sires.

Key salient beliefs
"If I select high daughter fertility ABV sires, I will…"
Have improved overall herd fertility.[1]
Have better profitability and/or lower costs.
Have less reproductive wastage and better AI efficiency.
Have less frustration and/or headaches about good cows not getting in calf.
Feel like I'm improving my herd and breeding towards a better animal.
Have restrictions on my bull choices.
Have compromised progress in non-fertility traits such as type or production.

[1]'Improved overall herd fertility' is a composite belief made up of more specific points such as having a tighter calving pattern, gaining better culling flexibility, improving cow longevity and 'having cows that keep getting back in calf'.

Table 3. People and groups that contribute to social norms around selection of high daughter fertility ABV sires.

Key referents
"Groups or people with an opinion about selecting high daughter fertility ABV sires include…"
Other commercial dairy farmers.
Other stud breeding dairy farmers.
My herd improvement centre.
My local vet.
Breed societies.
My AI tech and/or breeding consultant.
Dairy Australia.
My semen seller/AI company.
People who buy (or will buy) my stock.

Table 4. Perceived barriers to selecting high daughter fertility ABV sires.

Perceived barriers
'Things that make it hard for me to select high daughter fertility sires include…"
Lack of confidence in the daughter fertility ABV (how it's calculated or in the data collected).
Lack of confidence in daughter fertility ABV reliability (in bull proofs).
Too much information (too hard or confusing) to sort through.
Price – high daughter fertility ABV sires are more expensive than other sires.
Difficulty looking up a bull's daughter fertility ABV (either because it isn't in the catalogue, or because a different value such as DPR is used).
Lack of confidence that genetic selection for fertility will have a measurable impact on my herd.

Postal survey

The data for this part of the project has been collected but the descriptive analysis is not yet complete.

Conclusions

It is too early in the study to draw definitive conclusions about either the ABV analysis or social research components. Our preliminary results indicate that the daughter fertility ABV is an accurate predictor of phenotypic performance for 3-week submission rate.

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