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DEMONSTRATING DIFFERENCES IN SURVIVAL AND FERTILITY OF HIGH AND LOW GENETIC MERIT COWS WITHIN AND ACROSS HERDS

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SUMMARY

Developing value propositions that resonate with farmers can improve on-farm adoption of genetic tools. Our aim was to illustrate differences in the performance of high and low genetic merit cows in a way that was understandable to farmers and service providers. Cows (n=10,734) with lifetime performance data from 29 herds were ranked into quartiles within herd-year contemporary groups based on parent-average derived genetic merit for the Balanced Performance Index (BPI), a multi-trait index that incorporates traits contributing to farm profit. Chi-squared tests were conducted within and across herd comparing genetic merit and lifetime number of calves and presence in the herd (present =1 or absent =0) after 100 days, 12, 18 and 24 months. On average, 5.3% and 6.1% more high BPI cows (top 25%) remained in the herd after 18 and 24 months, respectively, compared to low BPI cows (bottom 25%). Over one quarter of low BPI cows only had one calf, while 55% of high BPI cows had 3 or more calves. These differences were significant ($p<0.05$) in the across-herd analyses, but few (≥20%) of the within-herd analyses. Average differences in fertility and survival breeding values of high and low BPI cows were small (<1 standard deviation). This, coupled with a small sample size for within-herd analyses limited the ability to detect differences from within-herd analyses. This study demonstrates how selection on the BPI leads to favourable responses in health and fertility, in a way that is easy for farmers to understand. Demonstrating and detecting these benefits at the individual farm level remains challenging. Studies like this one that use datasets that are representative of the information farmers are using in decision making are important to help develop meaningful case studies to support extension and engagement efforts.

INTRODUCTION

Adoption of genetic and genomic tools can be facilitated through the development of value propositions that resonate with farmers. Previous studies (i.e., Ramsbottom *et al.* (2012)) that sought to demonstrate the link between genetic potential and performance present data collated from many farms. While this approach is valuable, farmers prefer localised, region-specific examples (Nettle *et al.* 2010). The long period between investment and impact on-farm and the fact that differences in traits expressed over a lifetime (i.e., survival, fertility) cannot easily be visualised add to the complexity of demonstrating the value of genetic and genomic tools. This study has focused on detecting differences in survival and fertility as these are traits of key importance in dairy production systems. The aim of this study was to quantify differences in the performance of high and low genetic merit cows in datasets representative of the information available on-farm.

MATERIALS AND METHODS

Cow performance, pedigree and breeding value (EBV) records were extracted for 29 dairy herds for a 10-year period from the national database housed by DataGene, first described in Newton *et al.* (2017). Updated EBVs (from May 2021 genetic evaluation) were extracted from the national database to incorporate updates to individual EBVs and the Balanced Performance Index, BPI, the Australian dairy industry's national multi-trait selection index (Axford *et al.* 2021). Only cows with records for their entire productive life as well as parentage recorded were retained for analysis. After removal of cows with incomplete records, 10,734 cows remained. Average herd size was 370 cows but ranged from 122 to 1,320 cows. Lifetime number of calves, and herd persistence, defined as present (1) or absent (0), 100 days, 12, 18 or 24 months after joining the milking herd was calculated for all cows. To reduce bias from cow's own information in EBVs, parent average EBVs were derived from multi-breed models facilitating across-breed analyses. Cows were grouped into quartiles within herd-year contemporary groups based on their genetic merit for the Balanced Performance Index (BPI) (n=10,734), survival (n=10,488) and fertility EBVs (n=10,459). Quartile 1 (Q1) contained cows ranked in the bottom 25%, quartile 2 (Q2) contained cows ranked in the 26th to 50th percentiles, quartile 3 (Q3) contained cows ranked in the 51st to 75th percentiles and quartile 4 (Q4) contained cows ranked top 25%. Genetic merit was treated as a categorical variable with 4 levels. Chi-squared tests were conducted within and across herds to test if there was a relationship between genetic merit and lifetime number of calves or herd persistence (present =1 or absent =0) after 100 days, 12, 18 and 24 months.

RESULTS AND DISCUSSION

Chi-squared tests detected statistically significant associations between genetic merit and number of calves and herd persistence in across-herd analyses but few within-herd analyses. On average, 5.3% and 6.1% more high BPI cows (Q4) remained in the herd after 18 and 24 months respectively, compared to low BPI cows (Q1) (Table 1). These differences were significant at both 18 (χ^2 = 18.22, df = 3, P <0.001) and 24 (χ^2 = 22.12, df = 3, p <0.001) months in the across-herd analyses. However, for the within-herd analyses, the association between herd persistence at 18 and 24 months and the BPI was only significant in 4 herds and 3 herds, respectively. When cows were grouped on Survival EBV, significantly (P <0.001) more Q4 cows remained in the herd at 12, 18 and 24 months; 5.2%, 8.9% and 9.8% more compared to Q1 cows, respectively. Although this was larger than grouping cows on BPI, significant differences in herd persistence were only found in 5 within herd analyses. After 100 days, differences in herd persistence were ~1% across quartiles with no statistical differences found in the across or within herd analyses.

Table 1. Percentage (and number) of cows present or absent 100 days, 12, 18 and 24 months after entering milking herd where cows were grouped into quartiles based on BPI and survival breeding value (EBV); bottom 25% (Q1), 26-50% (Q2), 51%-75% (Q3), top 25% (Q4)[1]

Quartile	100 days		12 months		18 months		24 months	
	absent	present	absent	present	absent	present	absent	present
Grouping based on BPI								
Q1	3.8 (102)	96.2 (2608)	21.8 (590)	78.2 (2120)	34.1 (923)	65.9 (1787)	45.6 (1236)	54.4 (1474)
Q2	4.1 (107)	95.9 (2481)	21.1 (546)	78.9 (2042)	31.8 (822)	68.2 (1766)	43.0 (1112)	57.0 (1476)
Q3	3.6 (95)	96.4 (2562)	20.4 (542)	79.6 (2115)	30.9 (820)	69.1 (1837)	41.5 (1103)	58.5 (1554)
Q4	3.1 (86)	96.9 (2693)	19.2 (533)	80.8 (2246)	28.8 (800)	71.2 (1979)	39.5 (1098)	60.5 (1681)
Across	χ^2= 4.32, df=3, p=0.23		χ^2=6.16, df=3, p=0.10		χ^2=18.22, df=3, p<0.001		χ^2=22.12, df=3, p<0.001	
Within	0 significant herds		0 significant herds		4 significant herds		3 significant herds	
Grouping based on survival EBV								
Q1	4.3 (95)	95.7 (2140)	22.6 (506)	77.4 (1729)	35.9 (803)	64.1 (1432)	47.8 (1069)	52.2 (1166)
Q2	3.6 (86)	96.4 (2329)	21.8 (526)	78.2 (1889)	32.4 (783)	67.6 (1632)	43.7 (1056)	56.3 (1359)
Q3	3.8 (102)	96.2 (2606)	21.6 (584)	78.4 (2124)	32.0 (867)	68.0 (1841)	42.1 (1141)	57.9 (1567)
Q4	3.1 (98)	96.9 (3032)	17.4 (546)	82.6 (2584)	27.0 (846)	73.0 (2284)	38.1 (1191)	61.9 (1939)
Across	χ^2= 4.86, df=3, p=0.18		χ^2= 28.33, df=3, p<0.001		χ^2= 50.6, df=3, p<0.001		χ^2= 52.97, df=3, p<0.001	
Within	1 significant herd		1 significant herd		5 significant herds		4 significant herds	

[1]Chi-squared test of genetic merit and herd persistence reported across and within herds

Around 26% of low BPI and low fertility EBV cows only had 1 calf (Table 2). In contrast, 54.8% of high BPI cows and 56.1% of high fertility EBV cows had 3 or more calves. As genetic merit increased, the proportion of cows who had 1 or 2 calves decreased and the proportion of cows who had 3 or more calves increased. These differences were significant in the across-herd analyses (BPI $\chi^2 = 38.2$, df = 6, p = <0.001; Fertility EBV $\chi^2 = 60.4$, df = 6, p = <0.001). In the within-herd analyses these differences were significant in 1 and 6 herds when cows were grouped on BPI and fertility EBV, respectively.

Table 2. Percentage (and number) of cows who have 1, 2, or 3+ calves over their lifetime where cows were grouped into quartiles based on BPI and fertility breeding value (EBV); bottom 25% (Q1), 26-50% (Q2), 51%-75% (Q3), top 25% (Q4)

Quartile	BPI			Fertility EBV		
	1	2	3+	1	2	3+
Q1	25.8 (700)	27.1 (735)	47.0 (1275)	26.1 (614)	27.8 (654)	46.2 (1087)
Q2	24.0 (622)	25.7 (666)	50.2 (1300)	23.6 (584)	27.7 (684)	48.7 (1205)
Q3	23.1 (614)	25.9 (688)	51.0 (1355)	22.9 (598)	25.7 (671)	51.5 (1346)
Q4	20.3 (563)	24.9 (693)	54.8 (1523)	20.6 (622)	23.3 (702)	56.1 (1692)

As the BPI places substantial weight on fertility and survival (Axford *et al*. 2021) it was expected high BPI cows would be more fertile and last longer. The statistically significant relationship between the BPI and lifetime number of calves and herd persistence in the across-herd analyses undertaken in this present study support this. Although there were few significant differences in the within-herd analyses, high BPI cows had more calves in 90% of herds (26/29) and had a higher proportion of animals present after 18 and 24 months in 76% of herds (22/29) which supports the across-herd analyses. These findings also align with our earlier studies (Newton *et al*. 2017; Newton *et al*. 2018), which used a previous iteration of the BPI. Here we also found few herds (<8%) had significant differences in fertility, expressed as number of calves/cow/year or calving interval. These previous studies analysed performance at the individual cow level whereas this present study was conducted at the herd level.

We have previously focused on productive life, the total length of time an animal remained in the milking herd as a key measure of survival (i.e. Newton *et al*. 2018). While this approach was able to consistently illustrate that high BPI cows lasted longer in the herd overall, survival is multi-faceted. The probability of culling due to infertility is high in early parities (Workie *et al*. 2021) so getting heifers back in calf for their second lactation can be a challenge on-farm. The measures of herd persistence, which used the binary definition of present or absent in the herd at a series of time points, chosen in consultation with industry were designed to test this. This approach successfully showed that improved survival of high BPI cows (and high survival EBV cows) begins to be expressed during the period of getting cows back in calf for the second lactation (12-18 months). As one of the barriers to uptake of genetics is the long period between investment and impact on-farm (Axford *et al*. 2015), the ability to show that the impact of genetic selection for survival can be seen as soon as 12 months after entry to the milking herd will be particularly helpful in extension activities.

Few statistically significant differences in herd persistence or number of calves were found in within-herd analysis in this current study. While there was 2.3 standard deviation units difference in BPI between Q1 and Q4 cows, average differences in fertility and survival EBVs were small, 0.6 and 1.1 standard deviation units, respectively. This may have limited the ability to detect differences from within-herd analyses. Herds where significant differences were detected, were generally larger than the average herd size and had above average variation in fertility or survival EBVs. This suggests that a small sample size, coupled with lower within-herd and within-herd-year contemporary group variation in fertility and survival EBVs limits the ability to detect significant differences at the individual herd level. Encouraging accurate reporting of reproduction and health events on-farm and ensuring pipelines exist to facilitate transfer of data captured on-farm into centralised databases will not only improve routine genetic evaluation but also improve our ability to illustrate the impact of genetics in farm businesses. Developing case studies on the value of genetics that are 1) scientifically robust, 2) accessible to non-scientific audiences, 3) use easily accessible data and 4) that align to farmer preferences for region- (or farm-) specific case studies remain a challenge. By working collaboratively with service providers and farmers and seeking iterative feedback, it is possible to develop case studies that align with this.

CONCLUSION

This study aimed to illustrate differences in the performance of high and low BPI cows in a way that was understandable to farmers and service providers. We focused on survival and fertility measures, as it has previously been found to be particularly challenging to detect and demonstrate the impact of genetic improvement on these traits. We demonstrated how selection on the multi-trait index, BPI, leads to favourable responses in survival and fertility. Significant differences in lifetime number of calves and herd persistence after 18 and 24 months were seen in across-herd analyses. Given the lag between investment in genetics and impact is a barrier to uptake of genetics, the ability to show genetic merit impacting survival as soon as 12 months after entry to the milking herd will be particularly helpful in extension activities. Detecting differences within-herd was made difficult by small sample size and low variation within contemporary groups. Trends in the within herd analyses were in support of across-herd analyses though. Illustrating significant differences at an across-herd level and showing similar trends at within-herd level can support the development of case studies that are scientifically robust, but also met farmer need for localised, regionally specific case studies.

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