Genetic trend in milk fat percent is highly responsive to the relative economic value of milk fat and milk protein in the New Zealand dairy sector

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Abstract

Milk components are important traits within Breeding Worth (BWSI), the national selection index of the New Zealand dairy industry. Breeding Worth is an economic index, and trait weightings are calculated based on the economic value (EV) that each trait contributes to a dairy farm business. The EVs are updated annually, but key parameters like the absolute and relative values of milk solids, and the relative value of milk fat and milk protein are included as a 5-year rolling average to mitigate against volatility in animal rankings. In 2015, the global price for milk fat began to increase, and between 2015 and 2022 the value of milk fat relative to milk protein rose rapidly year on year. The increase in the dollar value of milk fat relative to milk protein was gradually mirrored in BWSI weightings, and although the response in milk fat yield was modest, a clear inflection in the genetic trend for milk fat percent was observed from 2018 onwards. We sought to understand the drivers for this change in the rate of genetic gain, especially given the multi-breed composition of the NZ dairy herd. For a trait like milk fat percent, which differs between the Jersey and Holstein-Friesian breeds, NZ farmers can use both breed substitution and within-breed selection to alter the performance of their herd. We report that both breed substitution and within-breed selection appear to have contributed to the genetic trend in milk fat percent. The use of Holstein-Friesian sires declined between 2015 and 2020 in favor of Holstein-Friesian cross Jersey sires. Similarly, a 15-year decline in the use of Jersey sires was reversed in 2015, with a small increase recorded between 2015 and 2020. The within-breed response to the change in relative weightings on milk fat and milk protein is also notable, demonstrating the power of coordinated selection towards a breeding objective. Our findings highlight the importance of carefully considering the approach used for determining weighting factors within a selection index, especially for traits as responsive to selection as milk fat.

Key words: *Genetic Trend, Milk Production, Jersey, Holstein-Friesian*

Introduction

The national breeding objective for the New Zealand (NZ) dairy sector is to breed cows that efficiently convert feed into profit. DairyNZ, and its subsidiary New Zealand Animal Evaluation Limited (NZAEL) are responsible for designing the national selection index ‘Breeding Worth’ (BWSI), which ranks animals according to their ability to meet this objective. The BWSI incorporates a range of economically important traits, each weighted according to its economic value to farmers. These economic values vary over time, and the weighting factors applied to each trait are updated annually in December to reflect current market conditions. The final BWSI assigned to each animal represents its ability to breed profitable replacement heifers for an NZ dairy herd, relative to other potential parents. The BWSI is widely used by farmers in NZ, and changes to the weightings and/or traits included in the BWSI have a noticeable effect on trait-specific genetic trends. For example, the fertility trait was introduced into BWSI around 2002, resulting in an obvious increase in the rate of genetic gain for this trait (Pryce et al., 2014).

The national herd in NZ is a highly admixed population, comprised of two major breeds, Holstein-Friesians (HF) and Jerseys (J), and their crosses. The BWSI is produced using across-breed estimated breeding values (EBVs), meaning that it is designed to provide farmers with an objective ranking of animals, irrespective of breed. Trait means differ between HF and J cattle for several traits that are economically relevant to farmers, and so it could be expected that the breed composition of the national herd might change in response to changes to the weighting factors in BWSI. Furthermore, where trait means differ by breed, the availability of more than one breed could be strategically used as a tool to more quickly respond to changing market conditions.

Holstein-Friesians and Jerseys differ in milk fat percent (DairyNZ & LIC, 2022), and between 2015 and 2022 the value of milk fat relative to milk protein rose rapidly year on year. The structural shift in the market value of milk fat was reflected in the weighting factors within the BWSI and, consequently, an increase in the rate of genetic gain for milk fat percent. Given that NZ farmers can use both breed substitution and within-breed selection to modify the milk fat percent of their animals, we sought to understand the drivers for this change in the rate of genetic gain.

Materials and Methods

Data

All animal data and EBVs presented in this analysis were provided by NZAEL.

Breed categories

Animals were assigned to breed categories based on pedigree-derived breed percentages. Animals that were 87.5% or greater HF or J were categorized as those breeds. Animals that were not 87.5% or greater HF or J, but whose HF and J percentage summed to at least 87.5% were categorized as HF cross J (HFJ). The all-breeds category included all recorded animals, including minority breeds such as Ayrshires.

Weighting factor of milk fat and milk protein over time

The current weighting factors for traits included in the BWSI are publicly available on the DairyNZ website at the following URL: https://www.dairynz.co.nz/animal/breeding-decisions/economic-values/. We obtained historic weighting factors from NZAEL directly (Figure 1). The weighting factors are presented in economic terms, and no attempt has been made to adjust for inflation.

Genetic trends for milk fat and milk protein

The genetic trend plots for milk protein percent (Figure 2) and milk fat percent (Figure 3) represent the mean EBVs of all recorded dairy cows, by birth year and breed. Animal counts increased over time and varied by age and breed. The number of animals contributing to the all-breeds category ranged from around 700,000 to around 1,200,000. The number of animals contributing to the HF breed category ranged from around 300,000 to around 360,000. The number of animals contributing to the J breed category ranged from around 80,000 to around 100,000. The number of animals contributing to the HFJ breed category ranged from around 250,000 to around 750,000.

Breed composition of the national herd

The breed composition plot (Figure 4) represents the proportion of all recorded cows in each birth year sired by either Holstein (H), HF, HFJ, or J sires. The number of animals represented in each birth year increased over time, ranging from around 640,000 to around 1,100,000 in more recent years.

Results & Discussion

Weighting factor of milk fat and milk protein over time

The weighting factor applied to milk fat in BWSI rapidly increased from 2017 to 2021 (Figure 1). Conversely, between 2014 and 2020, there was a decrease in the weighting factor applied to milk protein. Between 2016 and 2022, the negative weighting on milk volume increased (data not shown), further incentivizing selection for dairy cattle with higher milk fat and protein percentages.

The findings of this study have important implications for the formulation and adjustment of BWSI weightings. The clear inflection in the genetic trend in milk fat percentage following the adjustment of weightings suggests that even modest economic signals can lead to significant genetic responses if selection pressure is sustained, especially for traits like milk fat percent, which exhibit moderate to high heritability (Ahlborn & Dempfle, 1992; Jayawardana *et al*., 2023). The study underscores the importance of considering long-term structural changes in market signals when setting selection index weightings, as powerful changes in animal performance can result from changes in both within- and between-breed selection decisions.

Genetic trends for milk fat and milk protein

The genetic trend for milk protein percentage has been consistently positive since 1995 (Figure 2). Conversely, the genetic trend for milk fat percent remained relatively flat until around 2017, at which point a positive inflection is clearly observed (Figure 3).

The study highlights the significant within-breed response to the changes in BWSI weightings. Successful within-breed selection for increased milk fat percentage demonstrates the potential for genetic improvement even within a single breed, provided that selection pressure is appropriately applied. This result emphasizes the importance of a national breeding objective and the need for continuous monitoring of selection indices. When clear new market signals are identified, indices should be adjusted to ensure they remain aligned with economic realities.

A second avenue for genetic progress in breed-divergent traits like milk fat percent is breed substitution. The breed composition of the NZ national dairy herd has changed dramatically in the past 20 years (Figure 4). Most notably the proportion of cows sired by HFJ sires has risen from a starting point of nearly 0 in year 2000 to around 35% in year 2022. Initially the increase in use of HFJ sires corresponded to a decline in the use of J sires, while the use of HF sires either remained stable or increased. During this period, breed substitution was likely to be limiting the all-breeds genetic trend for milk fat percent. Around 2015 J sire use stabilized, and then began to increase slightly around 2017. At the same time, the use of HF sires began to decline in favor of HFJ sires, further increasing the proportion of J genetics contributing to the national herd. From 2017, breed substitution may have supported the positive genetic trend for milk fat percent in both the all-breeds and the HFJ category.

The all-breeds genetic trend for milk fat percentage has likely been influenced by both breed substitution and within-breed selection. The recent decline in the use of HF sires in favour of J cross HF sires, coupled with the reversal of the long-term decline in J sire usage, indicates a potentially strategic shift among NZ dairy farmers in favour of J genetics. The ability to utilize breed substitution to increase milk fat percentage of the national herd highlights the importance of maintaining genetic diversity and the availability of multiple breeds with differing trait characteristics. The strengths of each breed represent a resource that can be exploited should market conditions require it.

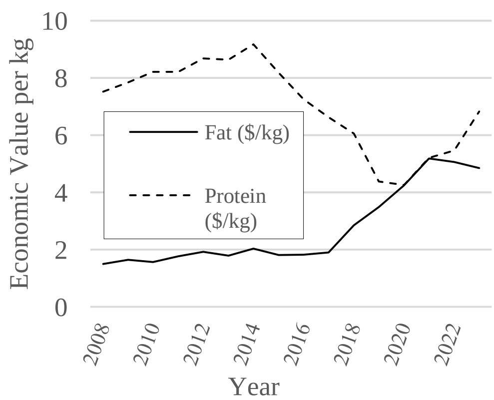

Figure 1**.** Weighting factor applied to milk fat and milk protein in the Breeding Worth Selection Index (BWSI) from 2008 to 2023.

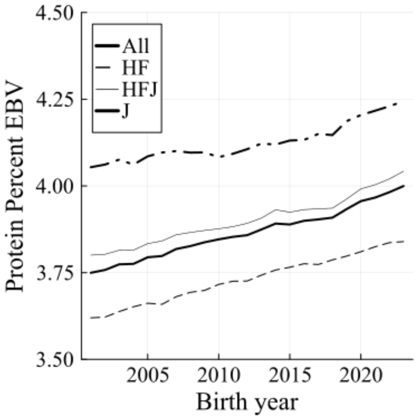

Figure 2. Genetic trend for milk protein percent by birth year for all female cows recorded in the New Zealand dairy sector (All), Holstein (H), Holstein-Friesian (HF), Holstein-Friesian cross Jersey (HFJ) or Jersey (J) cows.

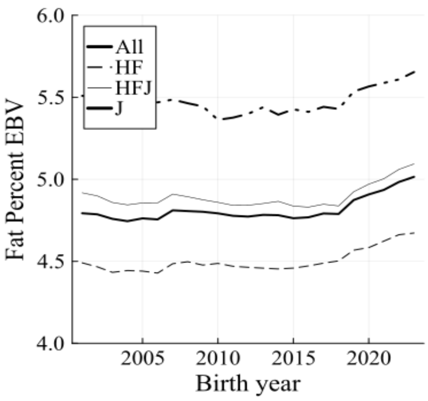

Figure 3. Genetic trend for milk fat percent by birth year for all female cows recorded in the New Zealand dairy sector (All), Holstein (H), Holstein-Friesian (HF), Holstein-Friesian cross Jersey (HFJ) or Jersey (J) cows.

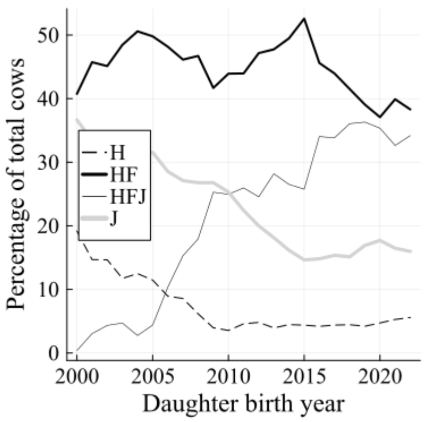

Figure 4. Proportion of cows in each birth year sired by either Holstein (H), Holstein-Friesian (HF), Holstein-Friesian cross Jersey (HFJ) or Jersey (J) sires.

Conclusions

In conclusion, this study provided valuable insights into the drivers of recent genetic gain in milk fat percentage in the NZ dairy herd. Although the genetic trend in milk fat percent appears to be primary driven by within breed selection, the occurrence of breed substitution highlights the opportunities that genetically diverse, mixed-breed populations can offer. This study contributes to a deeper understanding of the mechanisms driving genetic improvement in milk components in the NZ dairy sector.

Acknowledgments

This research was funded by NZ dairy farmers, through DairyNZ Incorporated (Newstead, Waikato, NZ).

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