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CORRELATION OF COW MORTALITY AND CULLING (SALE) RATE WITH SELECTED TYPE TRAITS IN AUSTRALIAN HOLSTEIN AND JERSEY CATTLE

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SUMMARY

Over the last 30 years, cow mortality rate (MR) on dairy farms has increased but the proportion of cows that are sold (i.e. culled rate, CR) has remained relatively unchanged. Cow MR on farms is more costly and of greater animal welfare concern than the removal of cows for other reasons. This study assessed the relationship of cow MR and CR with type traits in Holstein (H) and Jersey (J) cows to better understand cow MR and CR. In H and J, the genetic correlations of MR with udder texture (0.38) and angularity (0.57) were positive and high. In H, the genetic correlation between MR and body condition score (BCS) was also moderate. This suggests increased MR is related to negative energy balance (poor BCS, more angularity). On the other hand, J cows with high scores for angularity, udder texture and udder depth which also produce more milk are less likely to be culled (low CR). In H, udder depth is the only trait associated with CR due to associated with udder health. Overall, this study showed that the value of some type traits for predicting cow MR and CR is different.

INTRODUCTION

Selection for longevity has resulted in positive genetic trend for the trait (VanRaden *et al*. 2016). On the other hand, cow mortality rates (MR) have increased from below 1% in 1990 to over 5% in 2015 in some countries (Compton *et al*. 2017; Thomsen 2023; VanRaden *et al*. 2016), though this could partly be due to improved recording. In Australia during the same period, cow MR increased from below 1% to about 4% (Haile-Mariam *et al.* 2023). The impact of increased cow MR on profitability is greater than that of culling because farmers incur additional disposal costs instead of income from the sale cows. Cow deaths are more costly because they usually happen early in lactation (Thomsen 2023). Cow MR is also of greater animal welfare concern than culling cows. In Australia, the correlations of some economic traits with cow MR were genetically different from those with culling rate (CR). For example, cow MR has unfavourable genetic correlation with milk yield (MY) but favourable correlation with fertility whereas CR had favourable correlations with MY traits. Furthermore, the analyses showed (Haile-Mariam *et al*. 2023) that the relationship between MY and CR was weaker in Holstein (H) than in Jersey (J). The high genetic correlation between MY traits and MR could be related to an increased incidence of metabolic diseases associated with negative energy balance (Schmidtmann *et al.* 2023). Among type traits, traits such as body condition score (BCS) and angularity may be associated with energy balance and resilience (Bengtsson *et al*. 2022; Schmidtmann *et al.* 2023). Therefore, the objective of this study was to assess if the associations of MR with some type traits are different from those with CR. Knowledge of the relationship of MR and CR with type traits can be used to develop approaches to improve health, resilience, and fertility of dairy cattle.

MATERIALS AND METHODS

The data for this study, described by Haile-Mariam *et al.* (2023), comes from Australian dairy herds that record cow termination dates, reasons, and pedigree information. Terminations were categorised as either death or sale. The study includes H and J cows born between January 1997 and 2020 and calved at least once between 1999 and 2023. As the recording of termination data is voluntary in Australia, we selected cows from herd-years with more than 30 calving events and total exit rates between 1.5% and 75% (Haile-Mariam *et al*. 2023). This resulted in removing 47% of herd-years and 18% of the calvings. For defining MR, the cows removed from the herd due to death during the lactation were coded 1 and those that remained in the herd or removed due to culling were coded 0. Similarly, for defining CR, the cows that were removed from the herd for all reasons except for death were coded 1 and the rest including those that died on the farm were coded 0. All cows were coded 0 at the end of each lactation before they are culled or died.

To estimate the correlations of MR and CR with type traits the two datasets were merged. The type traits selected are previously known to be related to survival, fertility, and mastitis resistance (Haile-Mariam *et al.* 2014) in Australian dairy cattle. The type data used for this study included 436,896 cows that had linear type scores on a scale of 1 to 9 and BCS on a scale of 1 to 8 (Haile-Mariam *et al*. 2014). The mean days in milk at classification were 138 and 130 days in H and J cows and the age at classification was 31 in H and 30 months in J cows, respectively. Table 1 shows the number of cows and the mean with the standard deviation of the traits. After the edits, only 25% of the H cows and 12% of the J cows had data on type traits like Angularity but only 23% of the H and less than 3% of the J cows had BCS data. To improve the accuracy of genetic correlation estimates of MR and CR with type traits, some cows with type data but without termination data were included in these analyses. Genetic and residual correlations between MR or CR and type traits were estimated using bivariate models by analysing MR and CR with one type trait (Table 1) at a time. When analysing MR and CR, the fixed effects fitted were: dry-off of year of lactation or termination year of cow and dry-off of month of lactation or termination month of cow, age at calving within parity, and herd-year-season of calving. Age at calving was fitted as a covariate (linear and quadratic). The fixed effects fitted when analysing the type traits were age (in months) and days at classification and age at calving (in months) fitted as covariates and month of calving and herd-classifier-round fitted as classes. When estimating the correlation of MR and CR with BCS, body depth (BD) was also fitted as a covariate. This was done after a preliminary analysis showed that adjusted BCS was more strongly correlated (-0.39) with fertility (calving interval) than the unadjusted (-0.28) suggesting that cows with deep body were given a higher BCS than others. The random effect fitted was the sires of the cows with the numerator relationship between the sires.

Table 1. Description of the data and the mean and standard deviation (SD) for important traits for Holstein (no. of lactations, 4791600) and Jersey (no. of lactations. 752959) cows

Trait	Holstein		Jersey	
	No. cows	Mean (SD)	No. cows	Mean (SD)
Mortality rate (%)	1460179	3.56(18.54)	216623	3.10(17.33)
Culling rate (%)	1460179	17.35(37.87)	216623	16.44(37.06)
Angularity	436227	5.85(1.10)	65677	6.48(0.91)
Body condition score	387157	3.98(0.69)	7221	3.98(0.74)
Body depth	436083	6.03(1.23)	65677	6.17(0.89)
Udder depth	436210	5.54(1.38)	65692	4.72(1.10)
Udder Texture	436226	6.12(1.19)	65692	6.43(0.95)

RESULTS AND DISCUSSION

The focus of this study was the genetic and residual correlations of MR and CR with selected type traits (Table 2) and builds on our earlier report of heritability for MR and CR (Haile-Mariam *et al*. (2023). In both breeds, the likelihood of death is higher for cows that are more angular and with higher scores for udder texture (Table 2). On the other hand, the possibility of culling was lower for cows with higher angularity or higher udder texture scores in J because high MY is an important reason for keeping cows to continue production (Haile-Mariam *et al*. 2025). In the current data, the genetic correlation between angularity and MY was higher in J (0.64±0.04) than in H (0.27±0.02). The genetic correlation of BCS with MR was favourable in H and the correlation became stronger (from -0.37 to -0.45) when BCS was adjusted for BD (Table 2). In J the relationship between BCS (unadjusted) and MR was low (Table 2) and was only -0.07 when BCS was not adjusted for BD. However, this may be partly because the number of J cows with BCS data was limited. On the other hand, BCS had negligible association with CR. The genetic correlations of BD with both MR and CR are similar in H but not in J (Table 2). Overall, in J, the genetic correlations of MR with type traits are different from those with CR which agrees with the negative correlation (-0.31) of MR with CR (Haile-Mariam *et al.* 2023).

Table 2. Genetic and residual correlations of mortality and culling with type traits including body condition score (BCS) in Holstein and Jersey cattle with standard errors (±)

Traits	**Holstein**			
	Mortality		Culling	
	Genetic	Residual	Genetic	Residual
Angularity	0.57±0.03	0.03±0.00	0.26±0.03	-0.04±0.00
BCS adjusted for BD	-0.45±0.04	-0.03±0.00	-0.08±0.03	-0.01±0.00
BCS unadjusted for BD	-0.37±0.04	-0.03±0.00	-0.08±0.03	-0.01±0.00
Body depth (BD)	0.35±0.03	0.01±0.00	0.38±0.02	-0.01±0.00
Udder depth	-0.12±0.03	-0.01±0.00	-0.34±0.02	-0.02±0.00
Udder texture	0.43±0.03	0.03±0.00	0.07±0.03	-0.04±0.00
	Jersey			
Angularity	0.44±0.08	0.03±0.01	-0.38±0.06	-0.10±0.01
BCS adjusted for BD	-0.13±0.19	0.03±0.03	0.13±0.16	-0.03±0.03
BCS unadjusted BD	-0.07±0.19	0.03±0.03	0.09±0.16	-0.04±0.03
Body depth (BD)	0.34±0.08	0.01±0.01	-0.07±0.06	-0.06±0.01
Udder depth	-0.20±0.09	0.00±0.01	-0.46±0.05	-0.04±0.01
Udder texture	0.38±0.08	0.01±0.01	-0.57±0.06	-0.09±0.01

The residual correlations between MR and type traits are small, but in the same directions as the genetic correlations for all the type traits considered in this study in H. Phenotypically for every unit increase in angularity and udder texture score in H, MR increased by 0.09±0.03% and 0.12±0.02%, respectively. In J, MR increased by 0.11±0.09% with angularity which was not statistically significant. On the other hand, in H for every unit increase in udder texture, angularity, and udder depth, CR (%) was reduced by -0.73±0.05, -0.59±0.06, -0.41±0.05, respectively. In J cows, the corresponding values were -1.55±0.19, -2.28±0.19, and -0.94±0.16. The reduction in CR in both breeds with increasing scores for angularity and udder texture suggests that farmers are reluctant to cull cows with high type scores and want to retain cows with high MY (Haile-Mariam *et al.* 2023). Unlike angularity and udder texture, the correlations and the effect of udder depth on CR are more the outcome of cows with shallow udder (i.e., high score) having better udder health than cows with deep udder, despite their poor MY (Abdelsayed *et al.* 2017). However, it is worth noting that all the phenotypic relationships observed in the current study could be biased because cows that are

removed from the herd early before type scoring and data of all cows in herds that do not participate in type classification could not be included.

The unfavourable genetic correlation of MR with angularity and udder texture and its favourable correlation with BCS in the current study, plus the associations between cow MR and high early MY (0.36 to 0.41) and poor fertility (0.54 to 0.68) in our previous study (Haile-Mariam *et al.* 2023) shows these type traits can serve as predictors of poor fertility (Haile-Mariam *et al.* 2014) and poor health that may lead to an increased risk of death. That cow MR data and the data of cows that exit the herd before the end of the lactation have similar genetic correlations with these type traits which was shown in Haile-Mariam *et al*. (2025) means by selective use of culling and MR data it is possible to develop genetic evaluations for health and resilience traits. For example, the genetic correlation estimates in Haile-Mariam *et al.* (2025) show that the likelihood of cow exit, especially up to 180 days, was higher for thin (poor BCS) and more angular cows. This implies that cows with high potential for MY, poor fertility, poor BCS, and high scores for angularity are more likely to exit early due to metabolic stress or die on the farm. Here the link between cow MR and early culling before the end of the lactation is that in both cases most cows exit the herd early in lactation. This agrees with the literature (Lassen *et al*. 2003; Schmidtmann *et al*. 2023) that showed moderate genetic correlations between some health and type traits.

CONCLUSIONS

MR has moderate to high genetic correlation with angularity and udder texture in both H and J suggesting that type these traits can be used as predictors of MR. In H, the genetic correlation between MR and BCS was also moderate suggesting these traits can serve as an indicator of negative energy balance which may lead to increased cow MR and an increased likelihood of exiting before the end of the lactation. On the other hand, type traits associated with high MY (angularity, udder texture) result in a decreased likelihood of CR, particularly in J cows. Overall, this study demonstrates that the usefulness some of type traits for predicting cow MR and CR is different.

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