
VOLUME 62 2002

Regression of traits-other-than-production phenotypes for cows milked once a day on estimated breeding values obtained from cows milked twice a day

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Abstract

The use of traits other than production (TOP) to aid selection for conformation fit-for-purpose offspring becomes more important as once-a-day (OAD) milking for whole or part season becomes more common. In 2013 Massey University Dairy 1 farm transitioned their mixed-breed herd milked twice a day (TAD) to an OAD spring-calving system. All cows on the farm were scored for 14 inspector TOP traits and four farmer-scored traits for a total of 1,163 records over five seasons (168 to 254 cows per year). The scores were adjusted for age of the cow and season. The adjusted phenotypes for all cows for each trait were then regressed on their corresponding nationally-produced TAD estimated breeding values (EBV), which had been calculated without using these phenotypes. The four farmer-scored traits had the lowest relationships with EBV. Estimates of regression coefficients near one were observed for the udder traits (udder support, rear udder, front teats, udder overall), dairy conformation and body capacity. This supports the use of national EBVs in OAD herds derived mostly from records on daughters in TAD herds.

Keywords: Traits other than production; once-a-day; estimated breeding values

Introduction

The number of cows milked per hour and per staff member increases as farm sizes increase. Given this additional workload per unit of time, once-a-day milking (OAD) has become increasingly common to deal with the time constraints of milking a greater number of cows (Davis 2005). There are more stressors on the udder under OAD milking where the udder holds around 50% more volume than is held between milkings during twice-a-day milking (TAD) (Lembeye et al. 2015). Accordingly, a OAD index has been developed which includes direct emphasis on udder support and both front and rear teat placement (LIC 2019). A method to determine the impact of this increased stress on the udder is to score cows for traits other than production (TOP). This involves a subjective scoring method for 14 inspector traits and four farmer scored traits. The inspector scored traits are: stature, live weight, body capacity, rump angle, rump width, leg angle, udder support, front udder, rear udder, front teat placement, rear teat placement, udder overall, dairy conformation and body condition score. The four farmer-scored traits are: milking speed, shed temperament, adaptability to milking and overall opinion (Advisory Committee on Traits other than Production 2014). The use of these scores to improve conformation and cow survival has previously been demonstrated (Cue et al. 1996; Berry et al. 2005; Rocha et al. 2017a; 2017b), however validation of the relationship between phenotype scores and nationally-produced estimated breeding values (EBVs) are not commonly reported.

The national breeding objective, Breeding Worth, includes TOP traits indirectly as predictors of survival, however, body capacity, udder support, rear teat placement, front teat placement and milking speed have been identified as being of greater importance for OAD cows to suit the OAD system, and these traits have been included with a direct economic value in a OAD selection index (LIC 2019). Bulls are evaluated for TOP based on their progeny milked in TAD herds. Therefore, there is a need to validate that the EBVs of these bulls are similarly expressed in their progeny milked OAD.

The objective of the present study was to validate the TOP EBVs in cows milked OAD by regression of adjusted OAD phenotypes on EBVs obtained from cows milked TAD.

Materials and methods

In 2013, Massey University Dairy 1 farm transitioned their TAD mixed-breed herd to an OAD spring-calving system. Since then, all cows on the farm have been scored each year for 14 inspector TOP traits and four farmer-scored traits, for a total of 1,163 records over five seasons (168 to 254 cows per year). All scores (inspector and farmer-scored) are on 1-9 scales, details of which are outlined in the TOP inspector manual (Advisory Committee on Traits other than Production 2014). The inspections all occurred between November and January each season when certified TOP inspectors were available. The breed compositions of all cows were available in 16ths: these breed proportions were used to classify the cows into Holstein-Friesian (F), Jersey (J), or FxJ crossbred categories. Either F or J was designated for an animal with a breed proportion ≥87.5% of the respective breed, FxJ crossbreds were designated as all animals intermediate to those two proportions. Numbers of cows of each breed are in Table 1 across the production seasons. Estimated breeding values for TOP and production traits were obtained for all cows which had that information, these values having been generated in the national animal evaluation.

Statistical analysis

The adjusted TOP scores were the residual value outputs from the MIXED procedure in SAS 9.4 (SAS Institute Inc., Cary, NC, USA) after fitting a model that included the fixed effect of age of animal at scoring (two years old, three years old and over three years old) and season of scoring (to adjust for differences between inspectors and timing) and the random effect of cow to account for correlated residual effects that would arise from the repeated inspections on the same cow. The estimate of the regression coefficient of adjusted TOP score on EBV for each trait was obtained using the GLM procedure of SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). Live weight EBVs are presented in terms of the measured live weight of the animal and not the TOP trait live weight score, and as such was excluded from further analysis due to differences in trait scale.

Results

Average scores for all type traits are presented in Table 2. Over the five dairy seasons, herd mean rump angle, leg angle, udder support, front udder, rear udder, rear teat placement and udder overall increased. Herd mean stature decreased over the years as J and FxJ crossbred cows made up a larger portion of the herd relative to F cows. There was no significant change in body capacity and front teat placement over the study period, whereas herd mean rump width, dairy confirmation and body condition score decreased. The teat placement improved, with the rear teat placement score moving from a narrow teat placement to a wider teat placement, whereas the front teat placement remained stable with a centred teat placement.

The results of the regression of adjusted phenotype on their respective EBVs, which are expected to be one in a robust evaluation system, are presented in Table 3. Regression coefficients for the slope that are closer to one show the best fit between adjusted phenotype and EBV. Udder support, rear udder and front teat placement had the regression coefficients closest to 1, (0.94, 0.96 and 1.04 respectively). The lowest slope coefficient was for adaptability to milking (0.10) indicating that realised differences in adaptability to milking were smaller than expected from EBV. Regression coefficients for rump angle, rump width, front udder and body condition score were all greater than one, indicating that realised differences in these phenotypes were greater than expected from EBVs, irrespective of the age group used to investigate it (two years old *vs* all ages). Dairy conformation and body capacity had regression coefficients of 1.08 and 1.10, respectively.

Table 1 Number of animals scored by season and predominant breed (Holstein-Friesian (F), Jersey (J) and FxJ Crossbred (FxJ) cows) at Massey University Dairy Farm 1.

Season	Breed F	Breed J	Breed FxJ	Overall
2013	18	21	129	168
2014	23	21	198	242
2015	70	64	126	250
2016	67	54	133	254
2017	56	54	129	239
All	234	214	715	1,163

Discussion

Culling of cows for bad udder conformation and selection of bulls based on the OAD selection index has been conducted in the herd at Massey since 2013, with previous studies showing that the udder conformation of the cows had been improving over this period (2013-2018) (Rocha et al. 2017a, 2017b). However, whether milking OAD or TAD, few farmers outside pedigree and progeny-testing herds normally undertake TOP scoring in their herds.

Cows in the present study had greater udder support and udder overall compared with the values reported by Cue et al. (1996), while the placements of the front teats and rear teats are similar. This implies that, since that 1996 study, the New Zealand national herd has improved its udder conformation traits without negatively impacting teat placement.

Table 2 Least-square means and standard errors of the mean for inspector-traits other than production scored across five production seasons at Massey University Dairy 1 farm

Trait	Season 2013	Season 2014	Season 2015	Season 2016	Season 2017
Stature	$6.3^{b} \pm 0.14$	$6.7^{a} \pm 0.13$	$6.2^{b} \pm 0.08$	$6.1^{b} \pm 0.08$	$5.7^{c} \pm 0.08$
Body capacity	$7.0^{b} \pm 0.10$	$7.3^{a} \pm 0.10$	$6.8^{b} \pm 0.06$	$6.6^{c} \pm 0.06$	$6.8^{b} \pm 0.08$
Rump angle	$3.9^{c} \pm 0.08$	$3.7^{d} \pm 0.08$	$4.6^{b} \pm 0.04$	$5.0^{a} \pm 0.04$	$4.9^{a} \pm 0.04$
Rump width	$6.4^{b} \pm 0.15$	$6.8^{a} \pm 0.14$	$6.1^{bc} \pm 0.08$	$5.9^{c} \pm 0.08$	$5.9^{c} \pm 0.09$
Leg angle	$6.3^{a} \pm 0.08$	$6.4^{a} \pm 0.08$	$5.7^{b} \pm 0.04$	$4.9^{c} \pm 0.04$	$4.8^{c} \pm 0.05$
Udder support	$5.7^{d} \pm 0.15$	$5.4^{d} \pm 0.14$	$6.2^{c} \pm 0.08$	$7.1^{a} \pm 0.08$	$6.8^{b} \pm 0.08$
Front udder	$5.7^{b} \pm 0.18$	$5.0^{c} \pm 0.17$	$5.7^{b} \pm 0.10$	$6.4^{a} \pm 0.10$	$6.2^{a} \pm 0.10$
Rear udder	$6.1^{c} \pm 0.16$	$6.1^{c} \pm 0.15$	$6.2^{c} \pm 0.08$	$7.1^{a} \pm 0.08$	$6.8^{b} \pm 0.09$
Front teats	$4.7^{a} \pm 0.09$	$4.3^{b} \pm 0.08$	$4.6^{a} \pm 0.05$	$4.6^{a} \pm 0.05$	$4.6^{a} \pm 0.05$
Rear teats	$6.3^{a} \pm 0.14$	$5.8^{b} \pm 0.14$	$5.8^{b} \pm 0.08$	$5.5^{c} \pm 0.08$	$5.9^{b} \pm 0.08$
Udder overall	$5.6^{bc} \pm 0.16$	$5.3^{c} \pm 0.15$	$6.0^{b} \pm 0.09$	$6.5^{a} \pm 0.09$	$6.4^{a} \pm 0.09$
Dairy conformation	$7.0^{ab} \pm 0.09$	$7.1^{a} \pm 0.09$	$6.9^{b} \pm 0.05$	$6.5^{d} \pm 0.05$	$6.6^{c} \pm 0.05$
Body condition score	$4.4^{c} \pm 0.05$	$4.5^{ab} \pm 0.05$	$4.6^{a} \pm 0.03$	$4.5^{bc} \pm 0.03$	$4.2^{d} \pm 0.03$

Table 3 Mean of estimated breeding values (EBV) and estimates of correlation, intercept and slope from regression of adjusted traits other than production score on EBV of dairy cows at Massey University Dairy 1 farm.

Trait	Mean EBV (±SD)	Intercept (±SE)	Slope (±SE)	Correlation
Farmer-scored				
Adaptability to milking	0.12 ± 0.15	0.03 ± 0.03	0.10 ± 0.18*	0.03
Temperament	0.12 ± 0.15	-0.06 ± 0.04	0.34 ± 0.20*	0.09
Milking speed	0.06 ± 0.11	-0.02 ± 0.04	0.48 ± 0.30*	0.09
Overall opinion	0.14 ± 0.14	-0.03 ± 0.04	0.34 ± 0.25*	0.08
Inspector-scored				
Stature	-0.17 ± 0.60	0.10 ± 0.04‡	1.32 ± 0.06*	0.69‡
Body capacity	0.14 ± 0.19	-0.19 ± 0.05‡	1.10 ± 0.20	0.25‡
Rump angle	-0.11 ± 0.15	0.19 ± 0.04‡	1.80 ± 0.19*	0.40‡
Rump width	0.01 ± 0.01	0.01 ± 0.06	2.31 ± 0.27*	0.37‡
Leg angle	0.04 ± 0.06	-0.07 ± 0.03‡	1.40 ± 0.45	0.14‡
Udder support	0.12 ± 0.22	0.14 ± 0.05‡	0.94 ± 0.22	0.19‡
Front udder	0.11 ± 0.24	0.03 ± 0.07	1.91 ± 0.25*	0.33‡
Rear udder	0.18 ± 0.22	0.04 ± 0.07	0.96 ± 0.24	0.18‡
Front teats	-0.01 ± 0.14	0.07 ± 0.03‡	1.04 ± 0.22	0.21‡
Rear teats	0.02 ± 0.26	0.04 ± 0.05	1.39 ± 0.19	0.31‡
Udder overall	0.14 ± 0.23	0.09 ± 0.06	1.22 ± 0.23	0.24‡
Dairy confirmation	0.13 ± 0.17	-0.07 ± 0.04	1.08 ± 0.20	0.24‡
Body condition score	0.05 ± 0.08	-0.07 ± 0.02‡	1.65 ± 0.21*	0.34‡

*indicates where the slope is significantly different to one (P<0.05)

‡indicates where the intercept or the correlation is significantly different to zero (P<0.05)

The estimates of the regression coefficients of adjusted phenotypic scores on EBVs indicate that generally the bull's EBVs could be used to infer the phenotypic expression of these udder traits in OAD-milked progeny. However, the differences expected from EBVs for adaptability to milking were not observed in offspring. In contrast, differences observed in rump angle, rump width, front udder and body condition score were greater than expected from their respective EBVs.

The farmer-scored values had poor correlations with the EBV data, despite the fact that the scoring system is the same for both this OAD herd and the TAD herds whose data are used in the national evaluation. Part of this may reflect the lack of calibration or training of farmers to allow consistent use of scoring. This lack of training can lead to only the extreme scores being used, such as ones and twos for the worst cows, then eights and nines for the rest, with under-representation or no representation of cows with intermediate scores.

In the present study, udder support, rear udder and front teat placement had the closest to expected regression coefficients, indicating that the change in EBV could be used to estimate the phenotypic expression of these traits. Body capacity and dairy conformation were also close to their expected regression coefficients indicating that these traits are not significantly affected by the milking frequency system in which they are scored. The use of these TAD breeding values would allow for reliable selection or culling decisions for OAD breeding.

Conclusion

Estimates of regression coefficients of adjusted phenotypes of TOP scores on their respective EBVs were close to the expected values for key traits, thus supporting the use of those TOP EBVs to select bulls for mating with cows in OAD systems. This genetic tool can be implemented to improve functional traits (udder support, front and rear teat placement, body capacity and dairy conformation). These traits are required in OAD milking systems to ensure greater survival and reduce cow wastage following the adoption of OAD milking. These findings support the inclusion of udder support, front and rear teat placement from TAD animals into the OAD selection index to improve the rate of gain on these traits within the industry.

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