BRIEF COMMUNICATION: Phenotypic selection of cows for lactation persistency

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INTRODUCTION

Lactational persistency is the degree to which early lactation yield persists during the lactation season. Though this is a desired dairy performance trait, it has not been directly selected for in New Zealand dairy populations. In spring-calving pasture-fed cows, peak lactation is reached soon after calving and then declines by about 10% per month (Davis *et al*., 2000) until the cows are dried off. It is known that some cows maintain their milk production through the milking season better than others. The shape of the lactation curve is of economic interest to the New Zealand dairy industry. Since most of the industry is seasonal in its calving pattern, processors must have enough capacity to cope with the volume of milk at peak lactation, hence much of the processing plant is underutilised during the remainder of the lactation cycle (Byles, 1995). Lactation persistency in New Zealand dairy cattle is heritable, although not as highly heritable as lactation milk yield. An unpublished industry estimate of heritability for persistency of milk yield in New Zealand Holstein-Friesian and New Zealand Jersey cows is 0.22 and 0.16 respectively (D.L. Johnson, Personal communication).

In the 2009/10 lactation season, a trial was carried out to monitor detailed physiological differences between cows with high and low persistency. This paper describes the selection of these two groups from AgResearch's dairy cow population. Persistency was defined as the ratio between autumn milk yield and spring milk yield. Phenotypic selection was carried out using lactation records from one large and two smaller herds.

MATERIALS AND METHODS

The majority of the animal data were selected from the AgResearch farm at Flock House, near Bulls (Herd 1). From the 2005/06 to 2008/09 lactations, cow herd test data in spring (October/November) and autumn (March/April) provided milk yields for the calculation of lactation persistency. There were 1,140 cows with at least one persistency record over the 4-year time period, resulting in 2,132 records for analysis, with an average period of 167 days of lactation between the spring, measured at an average of 58 days in milk, and autumn milk yields.

Data from cows present in two smaller herds were selected from the 2006/07 to 2008/09 lactations at the AgResearch Ruakura Dairy No. 1 (Herd 2) and Dairy No. 2 (Herd 3) farms. In Herd 2 weekly milk yields were available and were averaged across a selected three-week period in early October and early March. Over three seasons, 219 persistency records were analysed from 149 cows.

In Herd 3, spring and autumn milk yields were selected from herd test data, as for Herd 1. Over three seasons, 467 persistency records from 303 cows were available, with an average period of 160 days of lactation between the spring, measured at an average of 50 days in milk, and autumn milk yields.

Persistency was calculated, for each cow x year record, as the ratio of late lactation milk yield to early lactation milk yield. Within each herd, persistency data were analysed across years with a repeated-animal model which included, where available, fixed effects for cow age (2, 3, 4, 5 to 9, 10+ years) and year of record, covariates for breed expressed as a fraction of Friesian ancestry, and days in milk (DIM), the interaction between year and DIM, plus a random term for cow. In Herd 2, DIM was not available, and for Herd 3, breed was not included as a fixed effect in the final statistical model. Estimates of the repeatability of persistency for each herd were obtained from a repeated-animal restricted maximum likelihood analysis (Gilmour *et al.*, 2009). The estimate of predicted lifetime persistency was used to classify each cow as high or low persistency.

In Herd 1, the ten cows ranked highest and ten cows ranked lowest for predicted lifetime persistency, which were present and due to calve before approximately the end of August 2009, were selected and transferred to the AgResearch Tokanui Farm for assessment of milk production. To enable selection of the highest ranked five cows and lowest ranked five cows across Herd 2 and Herd 3 that were transferred to Tokanui, predicted lifetime persistency values were deviated from the respective herd mean and combined.

The milk production of the 15 High and 15 Low cows selected from Herds 1 to 3 was assessed by recording yield data in 2009/10 at Tokanui. Daily milk yields, which were recorded automatically,

TABLE 1: Number of records and mean, residual standard deviation (RSD), coefficient of variation (CV) and repeatability (± standard error (SE)) of lactation persistency in Herds 1, 2 and 3, with numbers of selected cows and mean predicted lifetime persistency for selected High and Low groups.

Parameter		Herd 1	Herd 2	Herd 3
All cows				
Number of seasons		4	3	3
Number of cows		1140	149	303
Number of persistency records		2132	219	467
Mean persistency		0.44	0.53	0.48
RSD		0.12	0.06	0.10
CV		0.28	0.10	0.20
Repeatability ± SE		0.16 ± 0.03	0.40 ± 0.10	0.11 ± 0.08
Selected cows for Tokanui				
Number of cows (High/Low)		10/10	2/1	3/4
Mean lifetime persistency	High group	0.47	0.74	0.51
	Low group	0.38	0.55	0.43

were accumulated over time, and differences between High and Low persistency groups were assessed by t-test. Where the daily record was missing it was estimated by fitting a Wood's lactation curve (Wood, 1967) for each animal.

RESULTS

Table 1 shows the mean, residual standard deviation and repeatability of lactation persistency in Herds 1, 2 and 3. Using a restricted maximum likelihood model the mean persistency for Herd 1 was 0.44 with a coefficient of variation (CV) of 0.28, and the repeatability estimate ± standard error was 0.16 ± 0.03. For Herd 2, the mean persistency was 0.53 with a CV of 0.10, and the repeatability was 0.40 ± 0.10. For Herd 3, the mean persistency was 0.48 with a CV of 0.20, and the repeatability was 0.11 ± 0.08.

In the largest data set (Herd 1), there were significant differences in persistency among cow age groups ($P < 0.001$) with predicted means of 0.44, 0.46, 0.45, 0.43 and 0.39 for the 2, 3, 4, 5 to 9, 10+ years of age categories, respectively.

Table 1 also shows the number of cows selected from Herds 1, 2 and 3 for transfer to Tokanui, and the mean predicted lifetime persistency for the High and Low groups selected. Across herds the means for the High and Low groups were 0.51 and 0.40, respectively, indicating the selected High group should be 27% more persistent.

Table 2 shows the unadjusted means and standard error of the difference (SED) of milk yields recorded at Tokanui where the selected High and Low persistency groups were randomised across two mobs during the 2009/10 lactation. The groups had similar milk yields up to mid-lactation at 125 DIM of 2,616 kg for the High group and 2,531 kg for the Low group, with an SED of 130. Thereafter between 126 and 250 DIM the High group had a greater milk yield compared to the Low persistency group of 1,706 versus 1,431 kg, SED 75 ($P = 0.001$). Summarising early and late 30-day periods specifically, persistency ratios were 0.51 and 0.40 for the High and Low groups, respectively ($n = 26$ cows), and a difference in ratio of 0.11 ± 0.03 ($P = 0.002$). The group selected for high persistency thus had a ratio that was 30% superior to that of the Low persistency group, compared with a prediction of 27%.

TABLE 2: Unadjusted means and standard error of differences (SED) of milk yields (kg) for the 2009/10 lactation recorded in cows pre-classified into High and Low persistency groups, for the total lactation period and selected 30-day early (E) and late (L) lactation periods.

Lactation period	Days in milk	Persistency group		SED	P value
		High	Low		
Early	1 - 125	2,616	2,531	130	0.52
Late	126 - 250	1,706	1,431	75	0.001
Total	1 - 250	4,322	3,962	185	0.06
For specified dates					
	43 - 73 (E)	702	662	38	0.29
	210 - 240 (L)	358	260	26	0.001
L/E ratio		0.51	0.40	0.03	0.002

DISCUSSION

These data show that persistency, as calculated, was a repeatable trait across years. Because of the availability of weekly milk yield data in Herd 2 we were able to obtain a more complete definition of seasonal yields than in Herds 1 and 3, and thus a lower coefficient of variation and a higher repeatability estimate. An earlier repeatability estimate, using weekly records as in Herd 2, gave a value of 0.45 ± 0.07 (Morris *et al.*, 2008). Different approaches to calculate persistency have been used when daily herd test records were available (Lopez-Villalobos *et al.*, 2005).

Phenotypic selection by the methods described was able to achieve significant differences in persistency. Second-half lactation yield was increased by 19 ± 5 % (P = 0.001) in the High versus the Low group (Table 2), leading to a 9.1 ± 4.7 % (P = 0.06) increase in full lactation yield. Clearly, a 19% advantage in the autumn yield of high persistency cows is of economic importance. An alternative method of classifying stock on persistency criteria would be by DNA analysis. Interval mapping approaches have detected quantitative trait loci (QTL) on chromosome 3 (Rodriguez-Zas *et al.*, 2002; Morris *et al.*, 2008). Future work on the high and low persistency cows in this study will be aimed at identifying molecular mechanisms regulating persistency.

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