GENOTYPE BY ENVIRONMENT INTERACTION BETWEEN REGISTERED AND COMMERCIAL HERDS FOR DAIRY TRAITS IN AUSTRALIA

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SUMMARY

The presence of genotype by environment interaction (GxE) between registered and commercial herds for dairy traits was investigated using Australian Holstein-Friesian data. The traits studied were milk yield, fertility, some type and workability traits and survival. To determine the importance of GxE the same traits recorded in registered and commercial herds were treated as different traits and genetic correlations between them were estimated using a bi-variate sire model. For most traits, genetic correlations between registry statuses were above 0.92 suggesting limited bull re-ranking as a result of having daughters in registered or commercial herds. Genetic correlations were slightly lower between commercial and registered herds for calving interval (0.92), likeability (0.88) and temperament (0.87). Heritability of likeability in registered herds was about 3 times that in commercial herds. The reason for the lower genetic correlations between registered and commercial herds for likeability and temperament may be that owners of registered herds considered the ancestry of cows and other attributes such as milk yield when scoring cows for these traits. For most traits current genetic evaluations using data from registered and commercial herds are adequate and better definition of the workability traits should help to further minimise GxE.

INTRODUCTION

The goal of a national genetic evaluation system is to identify sires that are consistently superior across all environments (type of herds) for economic traits. A recent analysis of milk production, survival and fertility data showed that bull re-ranking was significant but small when environments were defined by environmental descriptors such as herd size, average production level, regions and calving system in Australia (Hayes *et al*. 2003; Haile-Mariam *et al*. 2008). Another reason for possible genotype by environment interaction (GxE) could be the registry status of herds. The herd management and production objective of registered herds could be different from those of commercial herds. Culling and selection decisions could vary between registered and commercial herds (eg Dekkers *et al*. 1994). In registered herds cows with good type and ancestry may be valued more than those with good milk yield or fertility. These differences could lead to re-ranking of bulls for some traits. Currently the genetic evaluation for all dairy traits does not consider registry status of animals. In the Australian Holstein-Friesian (HF) breed the proportion of registered animals in the total population, which is about 29% (Monro 2004) may not be large, but their contribution to genetic progress could be higher than expected from their population size. The effect of GxE on the accuracy of selection and overall efficiency of selection schemes is documented (Mulder and Bijma 2005). Uncertainties about the possible impact of GxE on bull ranking can reduce the creditability of the genetic evaluation systems and the use of the results. Therefore, testing for the presence of GxE and informing farmers about its effect could help to increase farmers’ confidence in the evaluation system. Knowing the extent of GxE could also lead to appropriate decisions to calculate ABVs. The objective of this study was therefore to test for possible GxE between registered and commercial herds by estimating genetic parameters.

MATERIALS AND METHODS

Calving and survival data of HF cows were extracted from the Australian Dairy Herd Improvement Scheme (ADHIS) database. Details of the milk yield and calving data used for this study are given by Haile-Mariam *et al*. (2008). These data were merged with either type or workability data. Workability traits (temperament, likeability and milking speed) are scored by farmers from 1 to 5 with the most docile, most liked and fastest milking cows given a score of 1. Type traits are scored by classifiers of the HF breed. Of the type traits, overall type and mammary system are composite traits scored from 1 to 15 but the rest are linear traits scored 1 to 9. Classifications before 18 months of age and after 45 months were excluded. Stage of lactation at classification between day 6 and day 365 was included. Lists of herds that are reported as registered or commercial were also provided by ADHIS. The commercial herds that are included are those that had data on either workability or type traits. Table 1 shows the structure of the data.

Table 1. Number of herds, number of cows and mean (standard deviation) of the traits for registered and commercial herds in Australia

Traits	Registered			Commercial		
	No. herds	No. cows	Mean(SD)	No. herds	No. cows	Mean(SD)
Milk yield, kg	853	63000	5946(1452)	3786	188441	4990(1284)
Fat yield, kg	853	63000	222(53)	3786	188642	192(47)
Protein yield, kg	853	63000	187(47)	3786	188565	156(41)
Survival, %	874	74306	84(36)	3808	213530	84(36)
Calving interval, days	865	58691	416(87)	3672	164781	402(79)
Likeability	853	63088	2.39(0.90)	3787	188642	2.45(0.85)
Temperament	853	63088	2.40(0.89)	3787	188642	2.45(0.86)
Milking speed	853	63088	2.49(0.87)	3787	188642	2.54(0.83)
Overall type	906	65953	9.98(1.66)	2386	59197	8.93(1.84)
Mammary system	906	65954	10.28(1.66)	2386	59193	9.31(1.82)
Udder depth	906	65888	5.87(1.13)	2385	59111	5.87(1.21)
Pin set	906	65952	3.90(1.33)	2386	59194	3.81(1.38)
Foot angle	906	65888	4.96(1.09)	2385	59114	4.77(1.09)
Angularity	906	65952	5.62(1.17)	2385	59193	5.44(1.18)
Body depth	906	65887	6.34(1.10)	2385	59110	6.10(1.16)
Udder texture	906	65952	6.19(1.15)	2385	59189	5.88(1.20)

All the available pedigree data of sires of the cows with records and their ancestors as far back as 1950 were included in the pedigree. The number of sires with progeny varied from 4320 for workability traits to 7611 for survival. The proportion of bulls commonly used in both type of herds varied from 54% for type traits to 75% for survival (of all bulls). Traits analysed were milk yield traits, survival, calving interval (CI), workability traits, and a selected number of type traits. All data were analysed fitting fixed effects such as herd-year-season of calving, age at calving, month of calving and the random effect of sires. In the case of type traits, the fixed effects fitted were age at classification, stage of lactation (days in milk) at classification, month of calving and herd-classifier-round. Genotype by registry status (registered vs. commercial herds) interaction was examined by treating performance recorded in registered herds as trait 1 and that recorded in commercial herds as trait 2. To test the significance of GxE, the log likelihood of a full model was compared to log likelihood of a model in which the genetic correlation between registry statuses was fixed at unity. A χ^2 test with 1 degree of freedom was used to test for the significance of GxE. Data analyses performed using ASReml (Gilmour *et al.* 2006).

RESULTS AND DISCUSSION

Mean and standard deviation for milk yield traits and CI were higher in registered herds than in commercial herds (Table 1). The means for most type traits were slightly higher in registered herds than in commercial herds (Table 1). On the other hand means for workability traits were slightly higher in commercial herds than in registered herds (Table 1). Differences in mean and variance in milk yield traits and CI between registered and commercial herds were similar to the difference between year-round and seasonal calving herds observed in Australian cows (Haile-Mariam *et al*. 2008). Based on means, standard deviation and phenotypic variance for milk yield traits and CI registered herds are more similar to year-round calving herds and commercial herds are similar to seasonal calving herds. Differences in mean milk yield traits between registered and commercial herds appear to be higher in the current data than reported by others (Powell and Norman 1986).

Phenotypic variances were higher in registered than in commercial herds for milk yield traits, survival, CI and workability traits (Table 2). The difference in phenotypic variance between registered and commercial herds observed in the current study is of the same magnitude as that observed between year-round and seasonal calving herds for milk yield traits, survival and CI (Haile-Mariam *et al*. 2008). Differences in heritability estimates were small but were generally higher in registered herds than in commercial herds for milk yield and most type traits (Table 2). Heritabilities of workability traits in registered herds were higher than in commercial herds. The biggest difference was for likeability which is a catch-all trait followed by temperament which is also closely associated with likeability because the most docile cows are also the most liked.

Table 2. Heritabilities and genetic correlations for milk yield, fat yield, protein yield, survival, calving interval and for workability and some type traits of registered and commercial herds

Traits	Registered	Commercial	Genetic correlation
	Heritability	Heritability	
Milk yield, kg	0.31 ± 0.02 (823900)[A]	0.29 ± 0.01 (639000)[A]	0.96 ± 0.01
Fat yield, kg	0.24 ± 0.02 (1212)	0.22 ± 0.01 (968)	0.98 ± 0.01
Protein yield, kg	0.25 ± 0.02 (778)	0.22 ± 0.01 (599)	0.96 ± 0.01
Survival, %	0.03 ± 0.01 (1237)	0.03 ± 0.0[B] (1190)	0.98 ± 0.04
Calving interval, days	0.03 ± 0.01 (6049)	0.03 ± 0.0[B] (4740)	0.92 ± 0.06
Likeability	0.29 ± 0.02 (0.66)	0.11 ± 0.01 (0.56)	0.88 ± 0.03[C]
Temperament	0.20 ± 0.02 (0.63)	0.09 ± 0.01 (0.56)	0.87 ± 0.03[C]
Milking speed	0.24 ± 0.02 (0.60)	0.14 ± 0.01 (0.50)	0.96 ± 0.02
Overall type	0.19 ± 0.02 (2.14)	0.17 ± 0.01 (2.47)	0.96 ± 0.02
Mammary system	0.22 ± 0.02 (2.22)	0.18 ± 0.01 (2.52)	0.99 ± 0.01
Udder depth	0.33 ± 0.02 (0.99)	0.33 ± 0.02 (1.11)	0.97 ± 0.01
Pin set	0.31 ± 0.02 (1.52)	0.32 ± 0.02 (1.60)	0.99 ± 0.01
Foot angle	0.15 ± 0.01 (0.94)	0.11 ± 0.01 (1.0)	0.99 ± 0.01
Angularity	0.21 ± 0.02 (1.03)	0.20 ± 0.02 (1.13)	0.98 ± 0.02
Body depth	0.32 ± 0.02 (0.88)	0.30 ± 0.01 (1.02)	0.98 ± 0.01
Udder texture	0.19 ± 0.02 (1.11)	0.15 ± 0.01 (1.21)	0.99 ± 0.01

[A]Phenotypic variance; [B]Standard error rounded to zero; [C]Significantly different from unity ($P < 0.05$).

Genetic correlations between commercial and registered herds for all traits were close to unity except for likeability, temperament and CI. Compared to results in Table 2 Haile-Mariam *et al.* (2008) estimated a genetic correlation of 0.83 for CI between split and year-round calving herds. For milk yield traits the lowest genetic correlation of 0.9 was estimated for fat yield between region 1 (New South Wales, Queensland, South and West Australia) and region 3 (Gippsland and

Tasmania). Genetic correlations for milk yield traits between calving systems were all higher than 0.9 (Haile-Mariam *et al.* 2008).

For subjectively scored traits such as likeability and temperament differences in heritability as well as genetic correlations below unity could be related to difference in perceptions and preferences of herd owners of registered and commercial herds (Dekkers *et al*. 1994). The way these two traits are perceived may vary between the two groups of herd owners. According to Beard and Jones (1991) the score for likeability was the response to the question: "all things being equal would you like more cows like this one in your herd? ". This could be perceived to include ancestry of the cow by breeders of registered cows and could mean that cows from a certain group of sires may be liked more than those from other groups of sires whereas scoring in commercial herds may not be associated with ancestry. The reason for the difference in heritability between registered and commercial herds and the low genetic correlation (thus possible GxE) for temperament may be related to its high correlation (~0.85) with likeability. The higher heritabilities for workability traits in registered than in commercial herds could also be because cows in registered herds are more consistently and accurately scored. Another additional reason could be that likeability in one group of herds is more closely associated with other highly heritable traits than in the other group of herds. To test this further we estimated genetic and residual correlations of likeability with milk yield. The result showed that genetic (-0.62 vs. -0.58) and residual (-0.30 vs. -0.28) correlations in registered herds between likeability and milk yield were slightly stronger than in commercial herds (results not tabulated elsewhere). This suggests that perhaps milk yield is considered as an additional criterion when scoring for likeability to a greater extent in registered herds than in commercial herds.

According to Robertson (1959) the impact of GxE is economically important if the genetic correlation of a trait expressed in different environments falls below 0.8. In this study genetic correlations were higher than 0.86 showing limited amount of sire re-ranking. These genetic correlations could be increased or GxE could be reduced further if both likeability and temperament are better defined. Genetic correlations of most traits recorded in registered and commercial herds were closer to unity than observed between Australian regions or calving systems (Haile-Mariam *et al.* 2008).

In conclusion, the genetic correlations between registered and commercial herds even for likeability and temperament are high enough and should not be of concern to the dairy industry. This means owners of both registered and commercial herds should have confidence in the appropriateness of the current genetic evaluation systems. However, better definition of the traits and helping producers to standardising the scoring should be useful.

ACKNOWLEDGEMENTS

This research is funded by Dairy Australia and Victorian Department of Primary Industries. We thank ADHIS for providing the data and Dr Kevin Beard for data extraction.

REFERENCES

Beard, K. and Jones, L. (1991) *Proc. Aust. Assoc. Anim. Breed. Genet*. **7:**425.
Dekkers, J.C.M., Jairath, L. K, and Lawrence, B. H. (1994*) J. Dairy Sci*. **77**:844.
Gilmour, A.R., Gogel, B.J., Cullis, B.R. and Thompson, R. (2006) ASReml User Guide Release 2.0 VSN International Ltd, Hemel Hempstead, HP1 1ES, UK.
Haile-Mariam, M., Carrick, M. and Goddard, M.E. (2008*) J. Dairy Sci*. **91**: 4840.
Hayes, B. J., Carrick, M., Bowman, P. and Goddard, M.E. (2003*) J. Dairy Sci*. **86**:3736.
Monro, G. (2004) In **11**th World Holstein Conference, Paris, France.
Mulder, H. A., and Bijma. P. (2005) *J. Anim. Sci*. **83**:49.
Robertson, A. (1959) *Biometrics* **15**:469.