ARE HIGH AUSTRALIAN PROFIT RANKING SIRES BEST IN ALL HERDS? FINDINGS FROM THE FEEDING THE GENES PROJECT

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SUMMARY

The effects of increasing Australian Profit Ranking (APR) were assessed in 5 herd feeding systems and at various levels of milk production. In total, 505 herds and 250,857 and 43,941 lactations for Holstein and Jersey cows, respectively, were used for analyses. Effects of sire APR on milk yield variables were positive in all feeding systems and at all herd average solids per cow levels. Effects were similar for the most commonly used feeding systems but were approximately twice as large in herds with a total mixed ration feeding system than in low bail feeding herds. Cows with higher sire APRs were just as likely or more likely to recalve by 20 months as cows with lower genetic merit. Thus selecting high APR sires had benefits in all feeding systems, supporting the use of the same APR across all of these feeding systems. Herd managers using artificial breeding should select high index sires with an appropriate semen price and Australian Breeding Values that are aligned with the breeding objectives for their herd.

INTRODUCTION

The APR, introduced by the Australian Dairy Herd Improvement Scheme (ADHIS) in 2001 as a national selection index for dairy cattle, was most recently revised in 2009 (Pryce *et al*. 2009), and replaced in April 2015 with a new economic breeding index, the Balanced Performance Index (BPI). At the same time, 2 additional breeding indices were also introduced: the Health Weighted Index (HWI) and the Type Weighted Index (TWI) (Byrne *et al.* 2015; Martin-Collado *et al.* 2015). These 3 new breeding indices are closely correlated with the APR (correlation coefficients 0.98, 0.96 and 0.95, respectively (Nieuwhof G, personal communication).

The Australian dairy industry is characterised by a diverse range of feeding systems and the Australian Breeding Values used to calculate APRs are based on animal performance data pooled across Australian herds across all feeding systems. However, some advisors and farmers have questioned the validity of the APR for specific situations i.e. they ask whether there is an important genotype by environment interaction (G*E). Several trials assessing genetic merit by feeding interactions have been conducted in research herds including Kennedy *et al*. (2003), Beerda *et al*. (2007) and Fulkerson *et al*. (2008), and numerous large scale cohort studies have compared cows of varying genetic merit in commercial herds with various environments. However, only a few of these latter studies compared effects of varying genetic merit between different feeding systems; recent examples include Kearney *et al*. (2004a, 2004b) and Ramirez-Valverde *et al*. (2010). No such studies have been conducted in Australia.

Milk production and cow longevity are important to herd managers. To describe 'lasting ability', recalving by 20 months can be used to collectively describe short to medium term reproductive performance, culling and death. Thus, G*E effects on recalving by 20 months are of interest as they would impact on cow survival, lifetime milk yields, herd culling policy and replacement rates.

Milk production per cow is generally lower where the feeding system consists of pasture and conserved fodder with low concentrate use, and is much higher in herds using the total mixed ration feeding system. Herd average milk yield is readily calculated with routinely collected milk recording data whereas feeding system data are not routinely collected. When studying G*E or assessing sires in different environments, it would be simpler to define environment as herd average milk yield than feeding system. Accordingly, it was also important to assess whether feeding system is a surrogate 'environment' for herd average milk yield when assessing G*E. This could also inform the nature of any interactions detected.

The major aims of the project were: a) to estimate the effects of APR on milk production, and recalving by 20 months in cows in commercial Australian dairy herds using various feeding systems; b) to ascertain whether these effects differ substantially between herds with different feeding systems; and c) to assess whether feeding system is a surrogate environment for herd average solids (i.e. fat plus protein) per cow when assessing G*E.

MATERIAL AND METHODS

In 2012, all herds in which at least 30 Holstein cows calved in 2011 and/or at least 30 Jersey cows calved in 2011 were selected from the ADHIS database. Herds with less than 50 cows calved in 2011 were excluded. Letters were sent to managers of the remaining 2016 herds asking them to complete a simple herd data questionnaire to identify their herd's feeding system. In total, 505 herds provided data suitable for analyses and cow and lactation data for these herds were obtained from ADHIS. From these herds, 250,857 and 43,941 lactations for Holstein and Jersey cows, respectively, were used for analyses. Each cow's sire's APR was as estimated by ADHIS on 20th August, 2012. Each lactation was classified as having been followed by another calving within 20 months or not.

For 2008, 2009, 2010 and 2011, each herd's feeding system was classified as follows: low bail (grazed pasture, fed other forages and fed ≤1t grain/concentrates in parlour during milking annually/cow); moderate/high bail (grazed pasture, fed other forages and fed >1t grain/concentrates per cow in parlour during milking); partial mixed ration (a portion of the ration was fed on a feed pad using a mixer wagon and cows are fed pasture for at least 9 months of the year); hybrid (a portion of the ration was fed on a feed pad using a mixer wagon and cows are fed pasture for 2-8 months of the year); and total mixed ration (cows are fed pasture for no more than 1 month of the year). These definitions were specified based on a scheme developed by Dairy Australia (Dairy Australia 2015). Herd average solids per cow were calculated for each herd-year as the averages of each cow's 305-day fat plus protein yields.

For all analyses, the unit of analysis was the individual lactation. Phenotypic relationships between sire APR and 305-day milk yield variables were assessed using multilevel linear models; relationships between sire APR and recalved by 20 months were assessed using logistic models with herd fitted as a random effect.

Additional analyses were conducted with ASReml (Gilmour *et al*. 2009) using a genetic model to estimate genetic correlations between feeding systems for 305-day milk volume, with a subset of the data containing 60,532 first-lactation Holstein records from 3136 herd-year-season (HYS) combinations across 439 herds. Of the 2293 sires, approximately 1/2 (1131) had daughters in just 1 feeding system while only 89 had daughters in all 5 feeding systems. Most sires (87%) had fewer than 20 daughters in any feeding system and only 5% had moderately-sized families (>19 daughters) in more than 1 feeding system. Thus, the power of this data set for evaluating genetic performance in more than 1 feeding system was not strong. For analysis, base ancestors were assigned to 1 of 58 genetic groups, HYS was fitted as a fixed effect, and separate residual and sire variances were fitted for each of the 5 feeding systems, with 3 alternative structures for the latter: diagonal, correlated (uniform), and factor analytic. A second genetic model was tested using random regression, with the average milk volume of each HYS as a simple (linear) environmental descriptor instead of feeding system.

RESULTS AND DISCUSSION

Effects on milk production. For Holstein cows, effects of sire APR on milk production variables were positive in all feeding systems but differed by feeding system (Table 1). They were approximately twice as large in total mixed ration feeding system herds compared with low bail feeding herds. However, effects were more similar for the more commonly used feeding systems (low bail, moderate to high bail, and partial mixed ration feeding systems). Effects of sire APR on milk volume and protein yield also differed by herd average solids per cow. Effects were positive at all herd average solids per cow levels. However, no such interaction was evident for fat yield.

Table 1. Estimated effects*of cow's sire's APR on 305-day milk production for lactations from Holstein cows by feeding system (95% CI)

Milk production variable	Feeding system				
	Low bail	Moderate to high bail	Partial mixed ration	Hybrid	Total mixed ration
Milk volume (l)	56.2 (40.9 to 71.5)	68.0 (60.4 to 75.6)	53.7 (39.8 to 67.7)	79.7 (58.8 to 100.6)	109.9 (75.1 to 144.8)
Fat yield (kg)	2.6 (2.0 to 3.2)	2.5 (2.2 to 2.8)	1.5 (1.0 to 2.0)	3.5 (2.7 to 4.3)	5.7 (4.4 to 7.1)
Protein yield (kg)	2.6 (2.1 to 3.1)	3.4 (3.2 to 3.6)	2.9 (2.5 to 3.4)	4.0 (3.3 to 4.6)	5.1 (4.0 to 6.2)

*Coefficients represent estimated change in milk production variable per 50 unit increase in the cow's sire's APR; coefficients were adjusted for maternal grandsire's APR and age at calving; herd and cow within herd were fitted as random effects

For milk volume and protein yield, the interaction between APR and feeding system was largely accounted for by interaction between APR and herd average solids per cow. In contrast, the interaction between APR and feeding system for fat yield was not accounted for by interaction between APR and herd average solids per cow. These results indicate that the biological determinants of G*E for fat yield differ from those for milk volume and protein yield. Features of feeding systems determine APR effects on fat yield. In contrast, factors associated with herd average milk yield determine G*E effects of APR on milk volume and protein yield.

For Jersey cows in herds using low and moderate to high bail feeding systems and partial mixed ration feeding, increases in sire APR increased milk volume, and fat and protein yields. Increases in milk volume, and fat and protein yield were smaller for the low bail feeding system than for the other 2 feeding systems.

In the genetic analyses of milk volume, a uniform structure was found to be statistically the best fit for the genetic correlation between feeding systems, with an estimate of 0.81±0.06. Data structure limited the power to test more complex correlation structures. The random regression model revealed a correlation of 0.81±0.08 between the slope of the regression and its intercept (i.e. between responsiveness to production level and genetic merit). Collectively these indicate that genetic expression for milk volume was strongly correlated across all 5 feeding systems, and that the superiority of bulls with high ABV tended to increase as the herd's average milk volume increased.

Effects on recalving by 20 months. Cows with higher sire APRs were just as likely (if not more likely) to recalve by 20 months as cows with lower genetic merit. Estimated effects of increasing APR on whether a cow recalved by 20 months were weakly positive across all except the total mixed ration feeding system, and across all herd milk yield categories; effects were stronger in herds with higher herd average solids per cow.

CONCLUSIONS

In all feeding systems, the daughters of higher APR sires produced more milk and were just as likely (if not more likely) to last in the herd as daughters of lower APR sires. This shows that herd managers do not need to feed high rates of supplements to benefit from selecting high APR sires and that the daughters of high APR sires are likely to last as long or longer in the herd than daughters of lower APR sires.

The magnitude of benefits of greater genetic merit varies between feeding systems (i.e. there was an interaction between genetic merit and feeding system). The response from selecting high APR sires was realised in all systems but was greater in herds using more intensive feeding systems (hybrid and total mixed ration). The biological determinants of G*E for fat yield differ from those for milk volume and protein yield. Features of feeding systems determine APR effects on fat yield. In contrast, determinants associated with herd average milk yield determine APR effects on milk volume and protein yield.

Given the very close correlations between APR and each of the 3 new indexes, similar conclusions should apply for these. In summary, herd managers using artificial breeding should select high BPI, HWI or TWI sires with an appropriate semen price and Australian Breeding Values that are aligned with the breeding objectives for their herd.

REFERENCES

Beerda B., Ouweltjes W., Sebek L.B.J., Windig J.J. and Veerkamp R.F. (2007) *J. Dairy Sci.* **90**: 219.

Byrne T., Martin-Collado D., Santos B., Amer P., Pryce J. *et al.* (2015) *Proc. Assoc. Advmt. Anim. Breed. Genet.* **21**: (in press).

Dairy Australia (2015) Australia's 5 main feeding systems. [Online]. Available at http://www.dairyaustralia.com.au/Pastures-and-Feeding/Feeding-systems/Flexible-feeding-systems.aspx (accessed 16 April 2015).

Fulkerson W.J., Davison T.M., Garcia S.C., Hough G., Goddard M.E. *et al.* (2008) *J. Dairy Sci.* **91**: 826.

Gilmour A.R., Gogel B.J., Cullis B.R., and Thompson R. (2009) ASReml User Guide Release 3.0 VSN International Ltd, Hemel Hempstead, HP1 1ES, UK (www.vsni.co.uk)

Kearney J.F., Schutz M.M., Boettcher P.J. and Weigel K.A. (2004a) *J. Dairy Sci.* **87**: 501.

Kearney J.F., Schutz M.M. and Boettcher P.J. (2004b). *J. Dairy Sci.* **87**: 510.

Kennedy J., Dillon P., Delaby L., Faverdin P., Stakelum G. et al. (2003) *J. Dairy Sci.* **86**: 610.

Martin-Collado D., Byrne T. J., Amer P. R., Santos B. F. S., Axford M. *et al.* (2015) *J. Dairy Sci.* **98**: 4148.

Pryce J.E., Van der Werf J.H.J., Haile-Mariam M., Malcolm B. and Goddard M.E. (2009) *Proc. Assoc. Advmt. Anim. Breed. Genet.***18**: 143.

Ramirez-Valverde R., Peralta-Aban J.A., Nunez-Dominguez R., Ruíz-Flores A., García-Muñiz J.G. *et al.* (2010) *Animal* **4**: 1971.