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GENETICS OF BODY CONDITION SCORE AND ITS RELATIONSHIP WITH FERTILITY, MILK AND SURVIVAL IN AUSTRALIAN HOLSTEIN CATTLE

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SUMMARY

First parity body condition score (BCS) data from the Holstein Association of Australia recorded between 1999 and 2012 were used to determine the heritability and genetic and environmental correlations of BCS with other economically important traits. Heritability estimates of BCS were 0.16 and 0.22 when estimated using single and multiple-trait (with other type traits) sire model analyses, respectively. Genetic correlations between BCS and milk yield traits were negative (~ -0.2). The genetic correlation of BCS with fertility and lactation length shows that BCS could be used as a predictor of fertility. Residual correlations of BCS with almost all the traits were in the same direction as the equivalent genetic correlations. The genetic trend in BCS as well as chest width (a highly correlated type trait) show a small decline in recent years, perhaps due to inclusion of liveweight breeding values in the Australian Profit Ranking. Although this trend is based on a small dataset and a short time span, there is a need to evaluate the consequences of selection for reduced live weight on fertility and health traits.

INTRODUCTION

Body condition of cows scored during the lactation is associated with milk yield, fertility and health of cows (Roche *et al*. 2009). However, the strength of these associations may vary depending on the production system, such as pasture based grazing or indoor feeding systems. For example, in the pasture-based dairy production system in New Zealand the genetic correlation of BCS with milk yield traits is near zero or positive (Pryce and Harris, 2006). But is negative in the US (Dechow *et al*. 2004) and Europe (Veerkamp *et al*. 2001). In Australia, pasture-based production systems dominate the States of Victoria and Tasmania, whereas more concentrate relative to forage is fed in the other States. Also condition scoring methods vary among countries (Roche *et al*. 2009), possibly as a result correlations with other traits and also variation in BCS may vary countries.

In Australia, monitoring the genetic trend of BCS is of interest because the Australian Profit Ranking (APR), the economic index, which was introduced about a decade ago, includes liveweight (LWT) predicted from type traits (stature, body depth and chest width). This was done to take account of variation in maintenance feed requirements related to body size. However, selecting for reduced LWT may have the unintended consequences, such as favouring cows with relatively poor condition score. Literature estimates (e.g. Veerkamp and Brotherstone 1997) show that in particular chest width is highly genetically correlated with BCS.

MATERIALS AND METHODS

In Australia, BCS is measured on a scale of 1 (thin) to 8 (fat) (Earle 1976) by professional type classifiers of the HAA once in the first parity. Data were available for cows that were also scored for type between 1999 and 2012. For comparison purposes and to examine the relationship between BCS and other traits, data of cows that calved from January 1994 were extracted from the ADHIS database. Other type data of cows with missing BCS or with BCS of below 1 and above 8 were included with missing BCS to avoid exclusion of data due to unintended selection. Finally approximately 430,000 cows of which 45% had valid BCS data were selected. About 90% of the type classifications over the years were carried out by 27 classifiers. Thus data of 34 classifiers, who scored less than 300 cows each, were excluded. Days in milk at classification varied from 1 to 500 days but for analyses reported in this study classification after 365 days were set to missing. Cows that were classified after 49 months of age and that calved for the first time after 38 months of age were also excluded.

To assess the relationship between BCS and other dairy traits of economic importance, the type data of cows were merged with milk yield and fitness data. Because the type data is managed by the breed society while the data on other traits by data processing centres (DPC) only about 55% of the cows with type data could be merged with their data for other traits. In the merged data, survival from first to second lactation was higher (i.e. 87%) than the average in Australian Holstein cows (i.e. 83%) which could be because cows culled early in the lactation are not classified. To examine if genetic correlations between BCS and other traits are influenced by the exclusion of data of cows not type classified, data of other cows were added if they were progeny of sires with type data and if they were contemporaries (the same herd-year-season-age, HYSA) to type scored cows with their type data coded missing.

A sire model was used to estimate the h^2 of BCS. The fixed effects fitted when analysing BCS (or type traits) included Herd-Classifier-Round, month of calving, age and days in milk at classification. Bi-variate models were used to analyse BCS with chest width in order to minimise the effect of selection on chest width on the h^2 of BCS. To examine the relationship between BCS and other type traits, BCS data of cows were analysed in multiple-trait models with type traits that were reported to be highly correlated. To examine the relationship of BCS with fertility (calving interval, calving to first service interval, pregnancy, first service non-return rate), production (daily milk yield close to 90-days, 305-day milk, protein, and fat yield) and survival, BCS data of cows were analysed using a set of tri-variate sire models (i.e. each analyses included BCS and lactation length (LL) because there was less selection on LL as almost all cows had LL data. The fixed effects fitted when analysing fertility, production, LL and survival included HYSA, month of calving and age at calving. For calculating EBVs for BCS an animal model was used. To illustrate the genetic trends, EBV of sires and cows with BCS data were plotted by birth year for BCS, chest width and bone quality.

RESULTS AND DISCUSSION

Month of calving, age and days in milk at classification had significant effect on BCS. Cows calving between June and Sept. were in poorer condition compared to those calving in Oct. to Dec. and Feb. to May. Older cows had higher BCS than younger cows. Cows classified early in lactation and late in lactation were in better condition than those scored in mid-lactation.

The estimated h^2 of BCS was 0.16 when analysed using a single trait sire model. The h^2 of BCS from a multiple-trait sire model was higher (Table 1). The h^2 for other type traits in Table 1 were within the range of estimates elsewhere (Veerkamp and Brotherstone 1997) and those used by ADHIS for genetic evaluation. The h^2 estimate of BCS was lower than estimates from some European countries (e.g. Veerkamp *et al*. 2001) but were similar to estimates from New Zealand (Pryce and Harris 2006), the US (Dechow *et al,* 2004) and Canada (Bastin *et al*. 2010).

Genetic correlations between BCS and selected type traits are shown in Table 1. Chest width had the highest genetic correlation with BCS, followed by bone quality and then angularity. Of the type traits used to predict LWT, BCS was least correlated with stature.

Table 1. Heritability (on diagonal), genetic (above diagonal) and residual correlation (below diagonal) and among body condition score and selected type traits

Traits	BCS	Bone quality	Stature	Angularity	Chest width	Body depth
BCS	0.22±0.01	-0.76±0.02	0.01±0.03	-0.70±0.02	0.81±0.01	0.48±0.02
Bone quality	-0.38†	0.28±0.01	0.07±0.02	0.71±0.01	-0.60±0.01	-0.19±0.02
Stature	0.04	0.00	0.38±0.01	0.12±0.02	0.14±0.02	0.17±0.02
Angularity	-0.30	0.48	0.06	0.23±0.01	-0.37±0.02	0.11±0.02
Chest width	0.39	-0.32	0.15	-0.13	0.24±0.01	0.71±0.01
Body depth	0.24	-0.13	0.15	0.13	0.47	0.34±0.01

†All standard error of residual correlations are approximately zero.

Table 2. Genetic (r_g) and residual (r_e) correlation between body condition score and fertility, yield and survival traits

Traits	r_g	r_e
Close to 90-day daily milk	-0.22±0.04	-0.06±0.0
305-day milk	-0.25±0.04	-0.06±0.0
305-day protein	-0.19±0.05	-0.04±0.0
305-day fat	-0.21±0.05	-0.04±0.0
Lactation length	-0.30±0.06	-0.05±0.0
Calving interval	-0.28±0.06	-0.05±0.0
Calving to 1st service interval	-0.45±0.09	-0.04±0.01
Pregnancy rate	0.10±0.13	0.04±0.01
1st service non-return rate	0.02±0.14	0.01±0.01
Survival to 2nd lactation	-0.02±0.06	0.01±0.0

Correlations of BCS with production, fertility and survival are presented in Table 2. All residual correlations regardless of the trait were close to zero, but most of them were significant as residual correlations were estimated with small standard errors. All genetic correlations with fertility traits were favourable meaning better condition cows had better fertility. Both milk yield early in lactation and 305-day milk yield have unfavourable correlations with BCS. These correlations were weaker than European (Veerkamp *et al.* 2001) and US studies (Dechow *et al.* 2004) but stronger than a study of New Zealand dairy cattle (Pryce and Harris 2006) and with the range of those reported by Bastin *et al.* (2010) from Canada. The genetic relationship between fertility traits such as CI and CFS with BCS were of similar magnitude to those observed in the US (Dechow *et al.,* 2004) and the UK (e.g. Wall *et al.* 2007). Others have reported genetic correlations that are more favourable than the current study suggesting that the value of BCS as predictor of fertility could be higher (Pryce and Harris 2006). Of all correlations, those involving survival and LL were different from those observed in New Zealand where a genetic correlation of 0.35 with LL and 0.26 with survival were reported (Pryce and Harris 2004). Both our results and those in New Zealand are different from those in the US (Vallimont *et al.* 2013) where the correlation between productive life and BCS were negative (-0.48). The near zero genetic correlation with survival may mean that both cows with poor condition (for poor fertility) and good condition (for low milk yield) are possibly culled in Australian. Wall *et al.* (2007) found that life span in the UK had a positive genetic correlation with BCS.

Figure 1 shows the genetic trend for BCS and chest width which appears to have started to decline with the animals born in 2004 which coincides with the inclusion of predicted LWT into the APR. It is also worth noting that at about the same time, the US also included LWT using similar predictors in their index, Net Merit (VanRaden 2004) which may also have contributed to the decline. Based on animals born before 2004 there was no clear trend in BCS and chest width showing that selection on milk yield traits is not the main reason for the decline. However, it is worth noting that these results are preliminary given the time period and the amount of data on BCS but suggest that there is a need to evaluate the inclusion of predicted LWT in the APR and its possible impact on health and fertility traits.

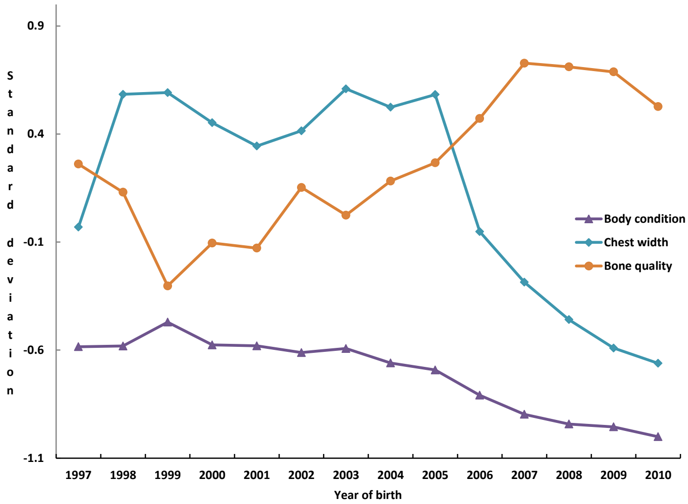

Figure 1. Genetic trend for body condition score, chest width and bone quality per genetic standard deviation

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REFERENCES

Bastin C., Loker S., Gengler N., Sewalem A. and Miglior F. (2010) *J. Dairy Sci.* **93**:2215.

Dechow C.D., Rogers G.W., Klei L., Lawlor T.J. and VanRaden P.M. (2004) *J. Dairy Sci*. **87:** 3534.

Earle D. (1976) *J. Agric. Victoria* **74:** 228.

Pryce J.E. and Harris B.L. (2004) *Interbull Bull.* **32**:82.

Pryce J.E. and Harris B.L. (2006) *J. Dairy Sci.* **89**:4424.

Roche, J.R., Friggens, N.C., Kay, J.K., Fisher, M.W., Stafford, K.J. and Berry D.P. (2009) *J. Dairy Sc*i. ***92:***5769.

Vallimont J.E., Dechow C.D., Daubert J.M., Dekleva M.W., Blum J.W, Liu W., Varga G.A., Heinrichs A.J. and Baumrucker C.R. (2013) *J. Dairy Sci.* **96**: 1251.

VanRaden, P.M. (2004) *J. Dairy Sci.* **87**: 3125.

Veerkamp, R.F. and Brotherstone S. (1997) *Anim. Sci*. **64**:385.

Veerkamp R. F, Koenen E.P.C. and de Jong G. (2001) *J. Dairy Sci.* **84:**2327.

Wall E., Coffey M.P. and Brotherstone S. (2007) *J. Dairy Sci*. **90**:1527.