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Milk Production of Adapted Saudi Holstein Cows in Relation to Body Condition Scores across Different Stages of Lactation

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ABSTRACT

Milk yield from adapted cows is facing problems due to varying climatic conditions and adaptability of imported animals. The main objective of study was to describe the relationships between body condition scores and daily milk yield across different days in milk. Genetic (co) variances between Body Condition Score (BCS) and test-day milk yield ($^{TD}Mk_{kg}$) were estimated using a random regression animal model extended to multivariate analysis. A cubic random regression was sufficient to model the changing genetic variances for BCS and milk across different Days in Milk (DIM). The milk yield data was obtained from the electronic herd records. The animal groups (milking cows) were evaluated according to the milk yield level and body condition scores. The additive genetic correlations between BCS and milk production showed high change over the lactation duration (pooled or separate parties). The highest additive correlations between BCS and $^{TD}Mk_{kg}$ were around 0.6 across 80-125 days in milk. Body condition scores during early and late part of lactation were negative and low related to milk production. This suggests that the highest genetic improvement in daily production from indirect selection on BCS should be based on measurements taken during the mid-lactation stage when the additive genetic variance for BCS is the largest.

Key words: Body condition score, heritability, random regression model, Saudi holstein, cows, test day milk yield, correlation

INTRODUCTION

One of the main obstacles in milk production is the acclimatization of high milk yielding cows under varying environmental conditions. Many studies have reported that the Body Condition Scores (BCS) are subjective, visual or tactile evaluations of the amount of subcutaneous fat on a cow (Boisclair *et al*., 1987; Edmonson *et al*., 1989). Some investigators have reported that milk yield, animal health and its reproductive performance is associated with the body conditions of the animal under investigation (Domecq *et al*., 1997; Shaver, 1997; Wildman *et al*., 1982). Economic efficiency of dairy production depends on all of these factors as well as the efficiency of feed utilization. In Saudi Arabia published study on BCS and its relationship with productive and reproductive traits is inadequate, rear and almost negligible. Garnsworthy (1988) suggested that the relationship between BCS at parturition and milk yield was variable. The cows with higher BCS at calving stage generally lost more body condition during lactation which could negatively influence the milk yield. Over fatted cows during parturition showed a great reduction in milk production and increased reproductive problems (Boisclair *et al*., 1986; Gearhart *et al*., 1990). They further concluded that fat or over-conditioned cows may represent extremes in BCS that are not typically seen in high yielding dairy herds. Also, Ruegg *et al*. (1992) showed that daily milk yield was not influenced by

BCS loss at parturition. The objective of the present study was to investigate the relationship between BCS and daily milk yield in Holstein dairy cows adapted to different environmental conditions.

MATERIALS AND METHODS

Data consisted of 121,325 test-day milk yield ($^{TD}Mk_{kg}$) and 45,349 body condition score (^{1-5}BCS) observations. Records were taken for the first three lactations of Holstein Friesian cows adapted to different environmental conditions. All studied traits were recorded on each test day between 5 and 365 or more days in milk. The criteria were that the cows must have at least the first lactation while the average was 1.2 lactations. Data were extracted from cows calving between 1989 and 1998. The $^{TD}Mk_{kg}$ observations were 52,121, 45,321 and 23,883 in the first three parities. The corresponding available BCS measurements were 21,211, 16,121 and 8,016 records. Full identification was available for most of animals. A small number of animals in the current data set were partially identified.

Statistical analysis: The random regression model used in this study was:

$$Y_{ijklm} = HTD + \sum_{n=1}^{n_p} \beta_{jlo}\ \chi_{klmo} + \sum_{n=1}^{n_p} \alpha_{klo}\ \chi_{klmo} + \sum_{n=1}^{n_p} \varphi_{klo}\ \chi_{klmo} + \varepsilon_{ijklm}$$

where, Y_{ijklm} is the mth test-day observation body condition score of the kth cow in the lth lactation, HTD_{il} is the independent fixed of jth herd-test-date for the lth lactation, n_p is the number of parameters fitted on days in milk or cow age or level of daily milk production function, , β_{jlo} is the oth fixed regression coefficient on jth days in milk or cow age or level of daily milk production effect within lth lactation, χ_{klmo} is the oth dependent trait on days in milk or cow age or level of daily milk production, α_{klo} is the oth random regression coefficient of additive genetic effect of the kth cow in the lth lactation on days in milk or cow age or level of daily milk production, φ_{klo} is the oth random regression coefficient of permanent environmental effect of the kth cow in the lth lactation on days in milk or cow age, ε_{ijklm} is the random residual.

Variance-covariance parameters for each of the current longitudinal traits (test-day milk yield and body condition score) were estimated using the software random regression package, DFREML (Meyer, 1998).

RESULTS AND DISCUSSION

Relationship between repeated measurements of BCS or $^{TD}Mk_{kg}$ across DIM: The genetic correlation between BCS at the beginning and end of lactation were above 0.80 showing an increase with progressing DIM (Fig. 1). The current results are in agreement with correlation value of 0.69 reported by Jones *et al.* (1999), 0.99 and 0.87 by Koenen *et al.* (2001) and 0.84 and 0.93 by Dechow *et al.* (2001). It means that BCS across different points of lactation could be treated as repeated traits. Therefore, early genetic selection for improving general animal health and body condition will lead animals to complete their productive life with good condition. Permanent environmental relationship between repeated measurements of Body Condition Score (BCS) were high only between the nearest measurements. The negative permanent environmental correlation was -0.28 between BCS at early Days in Milk (DIM) and BCS during the late part of lactation.

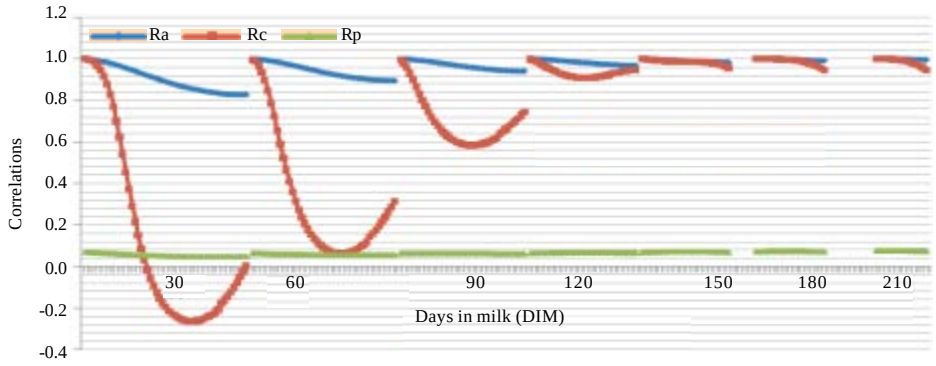

Fig. 1: Additive, permanent environmental and phenotypic correlations between repeated measurements of body condition score (BCS) at different points of days in milk (DIM)

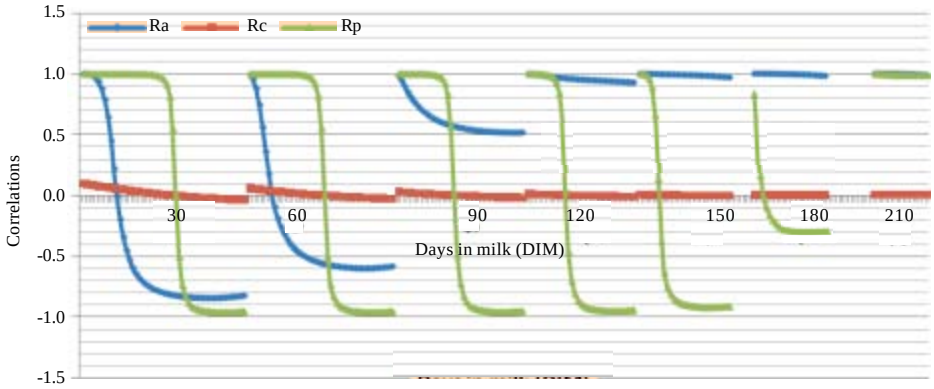

Fig. 2: Additive, permanent environmental and phenotypic correlations between repeated measurements of test-day milk yield ($^{TD}Mk_{kg}$) at different points of days in milk (DIM)

Additive relationship of early $^{TD}Mk_{kg}$ during the first 60 DIM were strongly negative with the corresponding measures during most part of lactation (Fig. 2). The $^{TD}Mk_{kg}$ at the fourth month of lactation were highly positive additive relationship with next measures toward trajectory end. These relationships ranged from 0.098-1.00. It means that daily milk production could be treated as repeated treat after the third month of lactation. The $^{TD}Mk_{kg}$ at the first month of lactation was highly negative additive correlation (>0.85) with production before the mid of lactation till to the end. The average of additive negative correlations of $^{TD}Mk_{kg}$ at 30 and 60 DIM with other measurements was -0.75±0.12 and -0.52±0.11, respectively. It means that cows starting their lactation with very high production will go to the lowest production very early (before the mid-lactation) till to the end of standard lactation length. Therefore, the current result did not suggest for selection for increasing milk production during early stage of lactation. The relationships between repeated measurements of $^{TD}Mk_{kg}$ due to the effect of environmental conditions were positive with very low values across different parts of lactation stage.

Relationship between $^{TD}Mk_{kg}$ *BCS across different stages of lactation: Additive genetic correlation between daily milk production at 30, 120 and 240 days in milk with subsequent BCS

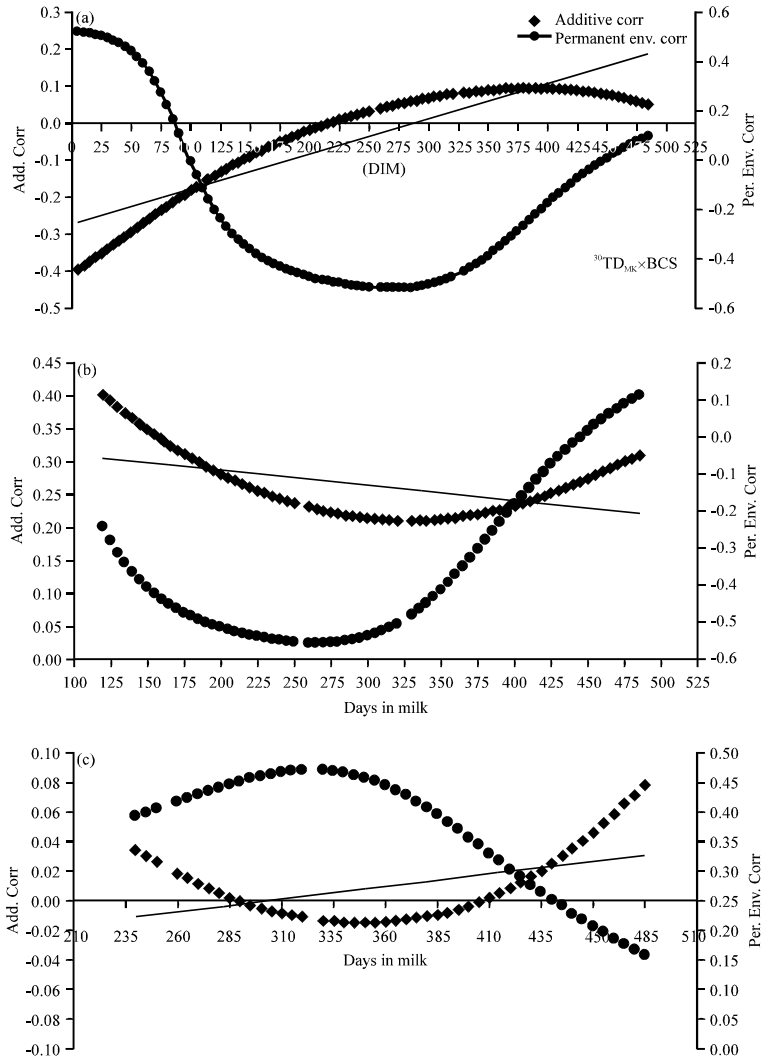

Fig. 3(a-c): Additive and permanent correlations between milk production at 30, 120, 240 days in milk with body condition score (BCS) measures at subsequent lactation parts (a) $^{30}TD_{MK}$ *BCS, (b) $^{120}TD_{MK}$ *BCS and (c) $^{240}TD_{MK}$ *BCS

measures are presented in Fig. 3. Additive genetic correlations of $^{30}Mk_{kg}$ with next BCS were changed to two different phases. The first phase was negative in reduction mode with progressing days in milk (from begging of lactation till to 200 DIM) and ranged from 0.0. to -0.4. The second phase starting was positive that extended from mid-lactation till to the end. The highest positive correlation between $^{30}Mk_{kg}$ with others was not more than 0.10. It means that daily milk production during early stage of lactation will not be the accurate indicator for body condition score during the late part of lactation. Permanent environmental correlations of $^{30}Mk_{kg}$ with next BCS appeared significant changes across different part of lactation. Additive correlation of $^{120}Mk_{kg}$ with subsequent measures of BCS changed into positive curve shape mode that ranged from 0.20-0.40 (Fig. 3). The limits of trajectory appeared to be the highest additive genetic correlations while the lowest values were obtained during the middle of correlation curve. The general linear trend for association between $^{120}Mk_{kg}$ *BCS was in reduction mode with progressing lactation. The correlation between

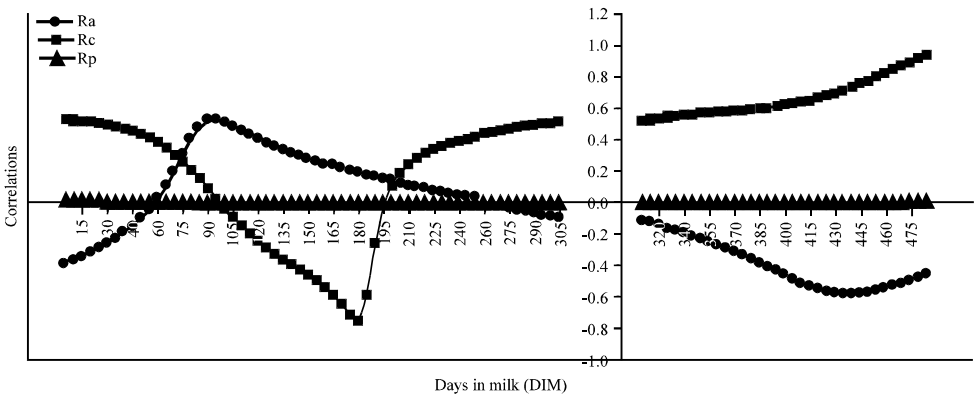

Fig. 4: Correlations between body condition score (BCS) and test day milk yield (TD_{MK}) across different stages of lactation

additive of $^{240}Mk_{kg}$ and BCS was negative having low values during the interval from 300-400 days in milk. Other positive correlations during the limits of trajectory were very low. It means that the contribution of additive genetic effect was low in controlling the relationship between $^{TD}Mk_{kg}$ and BCS during the late part of lactation. On the other hand, permanent environmental correlations were mostly in positive mode. The Permanent environmental correlation of $^{240}Mk_{kg}$ with BCS ranged from 0.38-0.48 toward the end of standard lactation length.

Additive relationship between BCS and $^{TD}Mk_{kg}$ at the same DIM changed to two different directions (Fig. 4). A negative additive correlation was found between $^{TD}Mk_{kg}$*BCS during early stage of lactation (the 1st fifty DIM) with a value of ~-0.40. The 2nd negative association was obtained near the end of lactation that came to >-0.60. Berry *et al.* (2003) found that all the correlations of BCS at different stages of lactation with milk production were negative and ranged from -0.14 to -0.53. In the current study, positive additive relationship between TD_{MK}*BCS were attained during interval from 50-265th days in milk in curve shape mode. Overall mean positive additive relationship between TD_{MK}*BCS was 0.29+0.11. Dechow *et al.* (2001) found that genetic correlations in first lactation between BCS at calving and milk production ranged from -0.02-0.22. The permanent environmental correlations were negative and strong between BCS at pregnancy check and milk production (-0.22 to -0.49) through the rest of lactation. If true, managing to reduce BCS loss during early lactation may be more successful by manipulating BCS late in the previous lactation and prior to calving than by attempting to limit BCS loss after the start of lactation. In general, it seems that higher BCS were more subject to stage of lactation effects. Thus selection strategy for improving BCS and/or milk production must be take DIM into account. The results of the present study in additive genetic correlation estimates between BCS and milk production in values and in direction are similar to those reported by Gallo *et al.* (2001) and Veerkamp and Brotherstone (1997).

CONCLUSION

The additive genetic correlations between BCS and milk production showed high change over the lactation duration (pooled or separate parties). The highest additive correlations between BCS and $^{TD}Mk_{kg}$ were around 0.6 across 80-125 days in milk. The body condition scores during early and late part of lactation were negative and low related to milk production. The permanent

environmental correlations were negative and strong between BCS at pregnancy check and milk production (-0.22 to -0.49) through the rest of lactation. This suggests that the highest genetic improvement in daily production from indirect selection on BCS should be based on measurements taken during the mid-lactation stage when the additive genetic variance for BCS is the largest. The genetic correlations between BCS at the beginning and end of lactation were above 0.80. In general, it seems that higher BCS were more subject to stage of lactation effects. Thus selection strategy for improving BCS and/or milk production must take DIM into account.

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