Genetic Relationship Between Repeated Measures of Body Condition Scores Across Different Levels of Daily Milk Production in Holstein Friesian Cows under Saudi conditions

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Received: 2/7/2010

Abstract: The objectives of the present study were to describe the relationships between repeated body condition scores across different levels of daily milk production. Body condition scores from producer and consultant-recorded data were available across different stages of lactation across the first three parities. Additive genetic correlations between repeated measures of BCS across different levels of daily milk production were high and ranging from0.79 to 0.98 within the 1st lactation. The lowest additive relationship occurred within the 2nd and the 3rd lactation between BCS at the lowest and at the highest milk production level. Permanent environmental correlations between repeated BCS are in reduction mode with increasing the distance between levels of daily milk production within all studied parities. BCS within the 1st and the 3rd parity are in strongly additive genetic relationship at the similar level of milk production. While the corresponding estimates between the 1st and the 2nd parities are low to moderate. In general if accurate genetic evaluations for BCS are to be obtained, recording the date of BCS evaluation should be considered in different breeding programs for improving the total benefit of dairy cattle projects.

Keywords: Body condition score, milk production, additive correlation, repeated measurements

INTRODUCTION

Body condition scores (**BCS**) are subjective, visual or tactile evaluations of the amount of subcutaneous fat on a cow (Boisclar *et al.* 1987; Edmonson, *et al.* 1989). Body condition scores are phenotypically associated with yield, cow health, and reproductive performance (Domecq *et al.*, 1997; Shaver, 1997; Wildman *et al.*, 1982). Economic efficiency of dairy production is dependent on all of these factors as well as efficiency of feed utilization. There are several BCS systems but most using of them is scores range from 1 (thin) to 5 (obese); scoring increments may be a tenth, quarter, or half points (Braun, *et al.* 1986). Ferguson *et al.* (1994) clarified and expanded the usefulness of BCS systems. In Saudi Arabia published research work on BCS and its relationship with productive and reproductive traits are very rare. Much of the information relating BCS to milk yield is based on studies conducted in the United Kingdom (Garnsworthy, 1988). Those studies utilized small numbers of cows, and breeds and management strategies were different from those in the US. Garnsworthy (1988) suggested that the relationship between BCS at parturition and milk yield was variable and that cows with higher BCS at calving generally lost more body condition during lactation, which could negatively influence milk yield. Over fattened cows during parturition showed a great reduction in milk production and increased reproductive problems (Boisclar, *et al.*, 1986 and Gearhart *et al.* 1990). They concluded that, the fat or over-conditioned cows may represent extremes in BCS that are not typically seen in high yielding dairy herds. Ferguson (1992) reported no observable effect for BCS at calving on daily milk yield. Also (Ruegg, *et al.* 1992) showed that daily milk yield was not influenced by BCS loss at parturition. Likewise (Pedron, *et al.* 1993) found that BCS at calving was not important to total milk production but change in BCS influenced peak yield and the shape of the lactation curve.

The objective of the present study was to investigate the relationship between repeated body condition scores across different levels of daily milk production in Holstein dairy cows adapted with Saudi conditions.

MATERIALS AND METHODS

Data consisted of 121,325 test-day milk yield (${}^{TD}Mk_{kg}$), and 45,349 body condition score (${}^{1\text{-}5}BCS$) observations. Records were for the first three lactations of Holstein Friesian cows adapted with Saudi Arabia environmental conditions. All studied traits were required to be recorded on each test day between 5 and 365 or more days in milk. Cows had to have at least the first lactation, while the average was 1.2 lactations. Data were extracted from cows calving between 1989 and 1998. ${}^{TD}Mk_{kg}$ observations were 52,121, 45,321 and 23,883 in the first three parities. The corresponding available ${}^{1\text{-}5}BCS$ measurements were 21,211, 16,121 and 8,016 records. Full identification are available for most of animals. Little part of animals in the current data set are partially identified. Some raw statistics of overall mean and standard error of BCS across different levels of daily milk production were illustrated in (Figure 1).

Statistical analysis of variance

The random regression model used in the current study was

$$Y_{ijklm} = HTD_{il} + \sum_{n=1}^{n_p} \beta_{jio} X_{klmo} + \sum_{n=1}^{n_p} \alpha_{kio} X_{klmo} + \sum_{n=1}^{n_p} \varphi_{klo} X_{klmo} + \varepsilon_{ijklm}$$

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Where:-
$Y_{ijklm} Y_{ijklm}$ is the $m^{th} m^{th}$ test-day observation of the $k^{th} k^{th}$ cow in the $l^{th} l^{th}$ lactation, $HTD_{il} HTD_{il}$ is the independent fixed of $j^{th} j^{th}$ herd-test-date for the $l^{th} l^{th}$ lactation, $n_p n_p$ is the number of parameters fitted on days in milk or cow age function, $\beta_{jlo} \beta_{jlo}$ is the $o^{th} o^{th}$ fixed regression coefficient on $j^{th} j^{th}$ days in milk or milk production levels within $l^{th} l^{th}$ lactation, $X_{klmo} X_{klmo}$ is the $o^{th} o^{th}$ dependent trait on days in milk or milk production levels, $\alpha_{klo} \alpha_{klo}$ is the $o^{th} o^{th}$ random regression coefficient of additive genetic effect of the $k^{th} k^{th}$ cow in the $l^{th} l^{th}$ lactation on days in milk or milk production levels, $\varphi_{klo} \varphi_{klo}$ is the $o^{th} o^{th}$ random regression coefficient of permanent environmental effect of the $k^{th} k^{th}$ cow in the $l^{th} l^{th}$ lactation on days in milk or milk production levels, $\varepsilon_{ijklm} \varepsilon_{ijklm}$ is the random residual. The following (co)variance structure was assumed:

$$V\begin{bmatrix}\alpha \\ \varphi \\ \varepsilon\end{bmatrix} = \begin{bmatrix} G \otimes A & 0 & 0 \\ 0 & P \otimes I & 0 \\ 0 & 0 & G \otimes I \end{bmatrix}$$

where:- G = genetic covariance matrix among random regression coefficients and traits, A= additive numerator relationship matrix, P = permanent environmental covariance matrix among random regression coefficients and traits, and E = residual variance for lactation n assumed to be constant throughout the lactation due to program limitations.

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 Version 3ß).

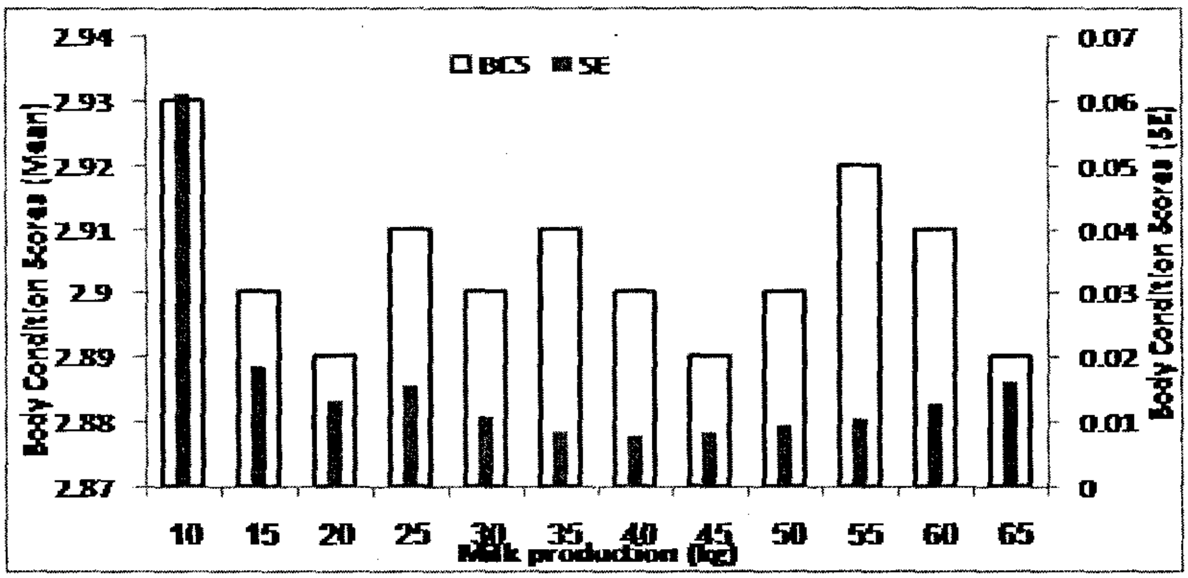

Figure (1): Estimates of overall mean and standard error of body condition scores across different levels of daily milk production.

RESULTS AND DISCUSSION

Relationship between BCS or TD_{MK} at different lactations:

Estimates of additive genetic, permanent environmental and phenotypic correlations between repeated measurements of either BCS or TD_{MK} across different parities are presented in (Table 1). Estimates of additive genetic correlations between 1st and subsequent lactations for TD_{MK} were higher than for BCS. BCS in the first three lactations could be considered as separate traits as evident from the low genetic correlations (0.112, 0.224). Thus, animals could continue with suitable BCS till life production end if they initiated their life production in a good body condition. Genetic correlations between BCS at 2nd and 3rd parities are very low and negative. While the corresponding estimates of permanent environment correlation are very high. These results indicate that, environmental conditions had a great role in controlling the relationship between measures of BCS at subsequent lactations. Dechow et al. (2001) concluded that, the lower limit of a healthy cow's body condition level may be under greater genetic control, whereas condition levels above the lower limit are influenced to a greater extent by management and environmental conditions. 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 lactation has begun. The current results are partially in agreement with reports of (Dechow, et al. 2001).

Table (1): Estimates of additive genetic (Ra), permanent environmental (Rc) and phenotypic correlations (Rp) between repeated measurements of either body condition scores (BCS) or test day milk yield (TD_{Mk}) across different parities.

Parities		BCS			TDMk		
		Ra	Rc	Rp	Ra	Rc	Rp
1st	2nd	0.112	0.538	0.023	0.888	0.145	0.788
	3rd	0.224	-0.419	0.039	0.596	0.026	0.096
	>3rd	0.881	0.490	0.176	0.981	0.374	0.821
2nd	3rd	0.885	0.540	0.159	0.135	0.006	0.835
	>3rd	-0.155	0.903	-0.014	0.960	0.466	0.796
3rd	>3rd	-0.053	0.848	-0.004	0.099	0.021	0.699

Correlations between parities for BCS at different TD_{MK}:

Relationships between BCS of different parities across different levels of daily milk production are presented in (Table 2). Correlations between the first three parities for BCS ranging from 0.134 to 0.426, 0.636 to 0.841, and 0.083 to 0.716, for 1st and 2nd, 1st and 3rd and 2nd and 3rd parity, respectively. BCS of the 1st lactation at the lowest level of milk production are highly correlated with corresponding estimates within the 2nd and the 3rd lactations. On the other hand BCS of the 2nd parity at the moderate level of milk production appeared to have high correlations (0.58 to 0.72) with other BCS within the 3rd parity. The lower limit of a healthy cow's body condition level may be under moderate environmental correlation with milk production through the late part of production life, whereas condition levels above the lower limit are influenced to a greater extent by management and environmental conditions. Phenotypic correlation estimates between repeated measures of BCS were not as strong, but were still positive, ranging from 0.02 to 0.09 for the relationship between early production life.

Table (2): Estimates of additive (R_a), permanent environmental (R_c), and phenotypic (R_p) correlations between measures of body condition scores of different parities across different levels of milk production.

	1st * 2nd			1st * 3rd			2nd * 3rd		
Mk	R_a	R_c	R_p	R_a	R_c	R_p	R_a	R_c	R_p
10	0.426	0.244	0.094	0.841	-0.503	0.119	-0.345	-0.601	-0.087
15	0.423	0.269	0.08	0.841	-0.495	0.107	0.083	-0.605	0.01
20	0.296	0.298	0.055	0.822	-0.479	0.084	0.539	-0.612	0.064
25	0.23	0.328	0.043	0.712	-0.446	0.071	0.695	-0.621	0.084
30	0.239	0.349	0.042	0.706	-0.379	0.071	0.716	-0.635	0.087
35	0.285	0.32	0.047	0.765	-0.253	0.077	0.703	-0.65	0.084
40	0.32	0.11	0.05	0.783	-0.043	0.084	0.654	-0.614	0.079
45	0.311	-0.216	0.048	0.738	0.179	0.088	0.576	-0.49	0.073
50	0.272	-0.332	0.042	0.695	0.226	0.091	0.497	-0.474	0.067
55	0.239	-0.332	0.038	0.703	0.138	0.093	0.448	-0.498	0.06
60	0.218	-0.299	0.036	0.712	0.032	0.088	0.475	-0.516	0.061
65	0.134	-0.262	0.025	0.636	-0.055	0.047	0.596	-0.528	0.088

Relationships between repeated BCS across levels of TD_{MK}:

The covariance functions were used to calculate additive genetic, permanent environmental and phenotypic correlations between repeated BCS observations at different milk production levels. Estimates are plotted in (Figure. 2). Correlations decreased with increasing distance of daily production level. The highest genetic correlations between BCS across different milk production levels were obtained within the first parity and ranging from 0.8 to 1.0. It means that BCS estimates tend to be repeated across different daily production levels at early production life. Clear reduction in additive relationship between repeated BCS occurred at the lowest level of milk production within the 3rd parity. On the other hand, relationship between BCS measures increased with decreasing the distance between TD_{MK} levels within the 3rd parity. Permanent environmental relationships between repeated measures of BCS across levels of TDMk are in reduction mode with increasing the distance between milk production levels within all parities. This means that, fatty cows during low level of milk production are not reliable indicator for their body condition score during high levels of milk production. In addition, BCS could not be considered as repeated measurements as evident from reducing their correlations with progressing calving age. It appears that, management practices for enhancing BCS are not the same across different calving ages, since permanent environmental correlations between repeated BCS are low in general.

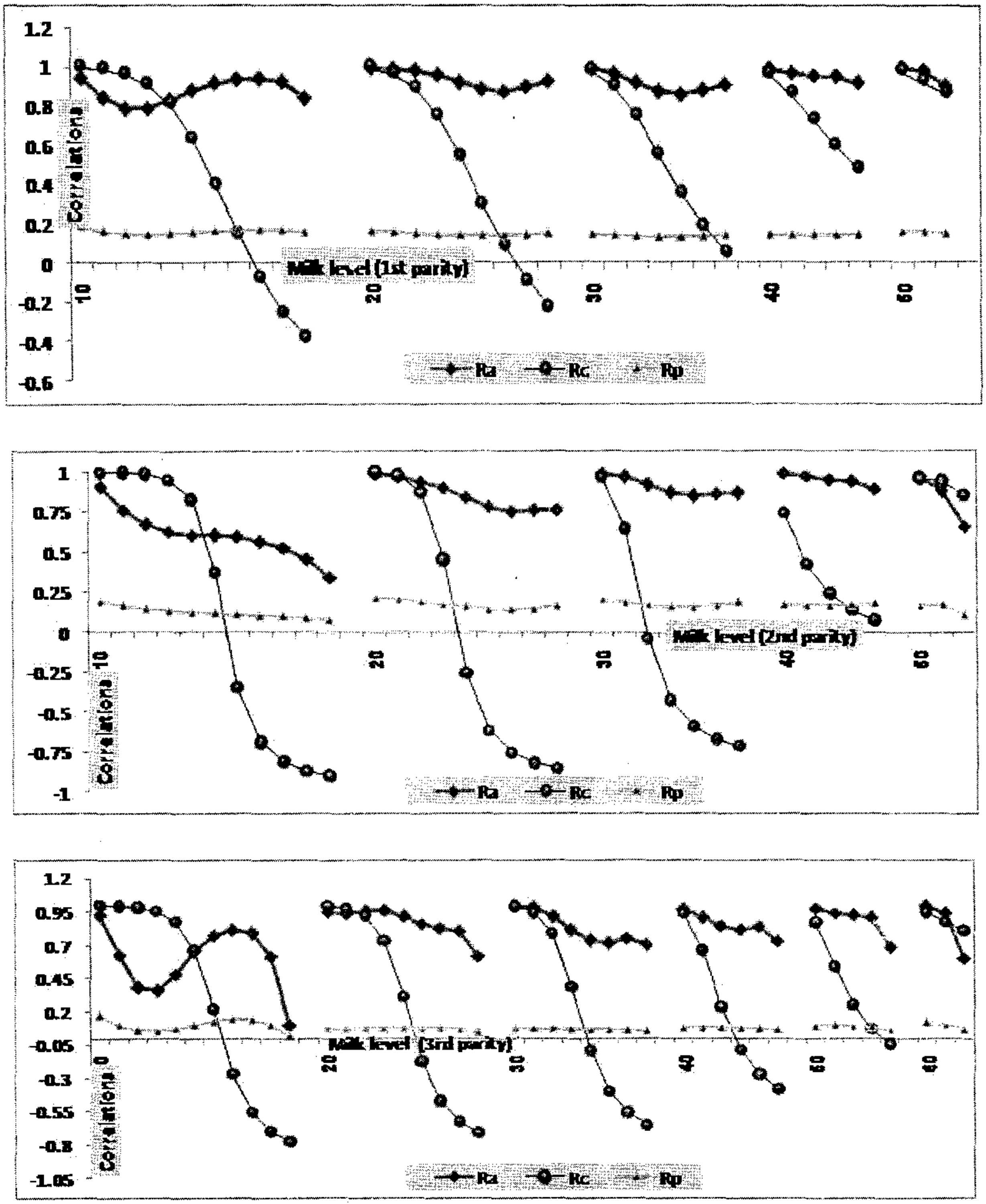

Figure (2): Correlations (within parities) between repeated measurements of body condition scores across different level of milk production

Relationships between repeated BCS across DIM within three levels of milk production:

Correlations between repeated BCS within different three levels of daily milk production were presented in (Figure 3). Additive relationships between repeated BCS were positive and in reduction mode with increasing the distances between measurements within low and high production levels. The highest additive correlation within low production level occurred between BCS across the nearest DIM.

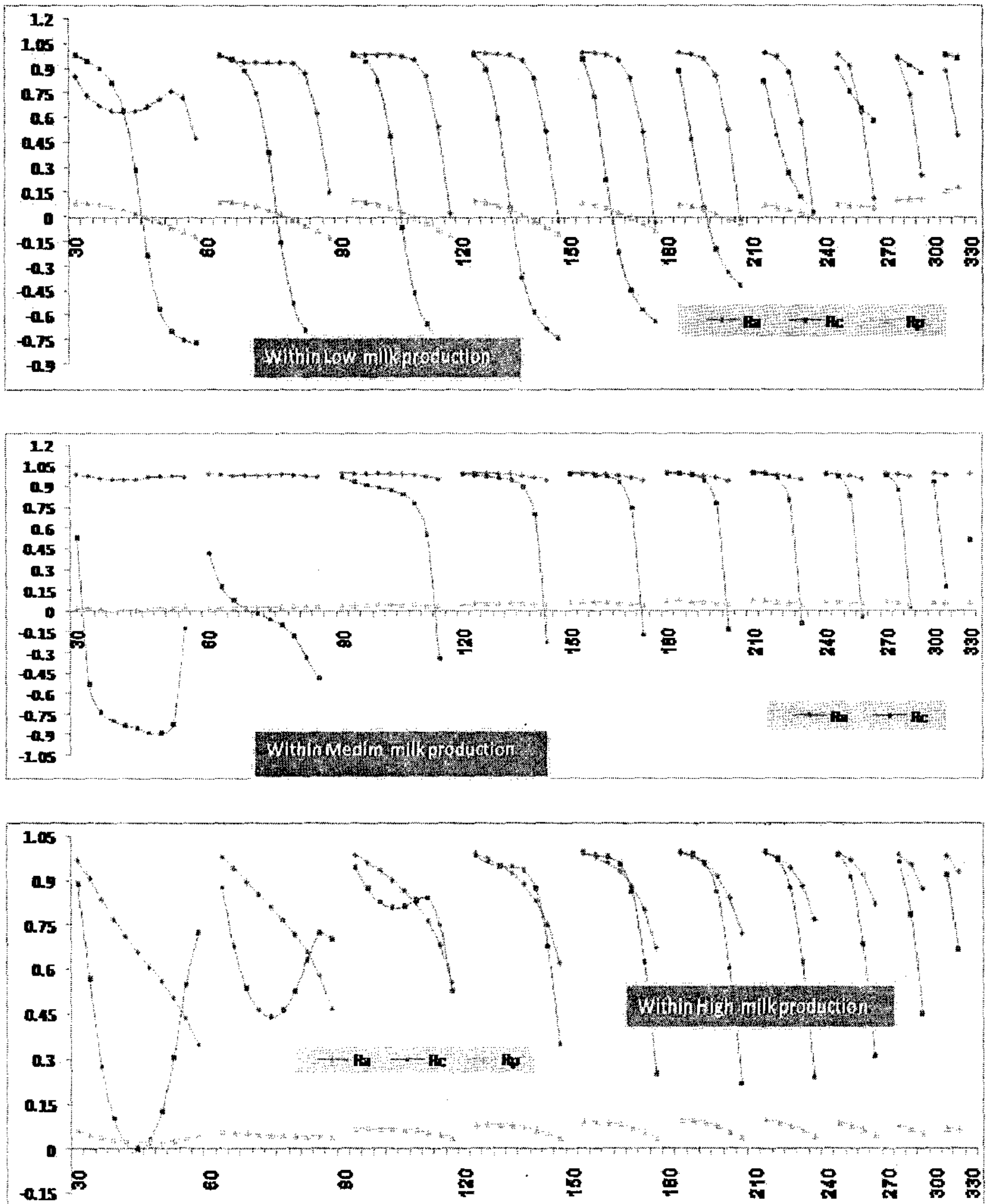

Figure (3): Relationship between repeated body condition scores across different days in milk within low, medium and high daily milk production in Holstein cows.

The rate of reduction in additive correlations between repeated BCS within high milk production level were greater than the corresponding estimates within the low milk production level. Therefore BCS could be treated as separate traits across DIM within high and low production levels especially between BCS at early and late DIM. On the other hand, additive correlation between BCS were very high ($\simeq$ 1.0) and changed in stable mode across DIM within medium production level. It means that, BCS could sustain their performance across different stages of lactation within medium milk production level. Permanent environmental correlations between BCS tend to decrease with progressing DIM and alter their sign from positive to negative during the late part of lactation. In general permanent environmental correlations had lower contribution than additive correlations in controlling the relationship between repeated measures of BCS.

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