Genetic parameters for 305 days milk yield and persistency across different calving ages using random regression analysis in Holstein Friesian Cows in Saudi Arabia

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Abstract: Persistency in dairy cattle can be used as an important economic selection criterion. Peak value in lactation can be used for genetic evaluation of dairy cattle performance. The aim of the present study was to determine changes in inheritance power of milk persistency (Mk_{Prs}) and 305 day milk yield (Mk_{305}) across different calving ages. A total number of 121,044 and 40,348 observations were used for genetic analysis of milk persistency and 305 day milk yield. Co-variance components of both studied traits were estimated using random regression animal model considering calving age as covariate function (25-80 months). Overall mean of heritabilities were Mk_{305}: 0.51 and Mk_{Prs}: 0.34 across different calving ages. Heritability trend of 305 day milk yield ($h^2_{MK_{305}}$) was in reduction mode with progressing calving ages and most of high $h^2_{MK_{305}}$ estimates were attained during early calving ages. It seems that, early selection for improving milk production could be useful within younger dairy heifers. Estimates of heritability for milk persistency ($h^2_{MK_{prs}}$) were in highest mode during early and late of production life. While the lowest inheritance power of Mk_{Prs} were attained during the wide interval within the middle production life. Additive genetic correlations between both traits were moderately high and positive (around 0.40) during early calving ages (<40 months). The results, suggest that early selection for improving economic productive performance could be possible in Holstein Friesian under Saudi Arabia conditions.

Keywords: Persistency, 305-milk yield, heritability, genetic correlations

INTRODUCTION

The rate of decline in milk yield following peak production is commonly known as persistency. Persistency is calculated as the month's milk divided by last month's expressed as a percentage. On average, the persistency should be about 94-96% (i.e. milk yield in each month is about 95% of the previous month's yield). After peak production milk yield of heifers will drop 0.2% per day while milk yield of mature cow will drop about 0.3% per day. Also persistency can be defined as how much the animal can be remaining on or around peak production for a longer time. Therefore, persistency could be considered as one of the most important economic dairy production trait.

Persistency of lactation yield is an important element of total yield and is advantageous because of better use of feed and reduction of stress due to high peak yield (Gengler, *et al.*, 2005). Dairy cows with the same peak yield can differ in total yield because of differences in persistency. A typical lactation curve can be described as increasing from initial yield at calving to maximum or peak yield, maintaining peak yield and decreasing from peak yield to the end of lactation (Van Der Werf *et al.*, 1998 and Szyda, 2001).

Charudhary *et al.* (2000) found that, the 9% heritability of milk persistency further indicates that response in the trait would be much lower as compared to traits like milk yield. Geetha *et al.* (2006) showed that, genetic correlations among genetic persistency in different days in milk and between genetic persistencies on the same day in milk were very high. The genetic correlations between genetic persistency for different days in milk and estimated breeding value for 305 days in milk was increased from 90 days in milk to 180 days in milk, and was highest around 240 days in milk which indicates a minimum of 240 days as an optimum first lactation length might be required for genetic evaluation of Indian Murrah buffaloes. Gravert and Baptist (1976) reported that, phenotypic (r_p) and genetic (r_a) correlations between initial milk yield and milk persistency were $r_p = -0.65$ and $r_a = -0.43$. Heritabilities were 0.26 and 0.18, respectively, for initial yield and milk persistency. Sharifi, *et al.* (2008) found that selection for milk production and persistency can be done based on part of lactation period due to higher correlation for breeding value between incomplete and complete lactation periods.

The objectives of the present study were to determine heritability estimates and additive and permanent environmental correlations for milk persistency and 305 day milk yield across different calving ages using random regression analysis.

MATERIALS AND METHODS

Data consisted of 121,044 records of milk persistency and 40,348 records of 305 day milk yield. Records were for the first eight lactations of Saudi Holstein Friesian cows in five dairy herds. Cows had to have at least one lactation, while the average was 1.35 lactations. 29,922 cows used in the present study as daughters of 854 sires and 13,247 dams. Data were extracted from cows calving between 1992 and 1997. All measurements of milk persistency were presented in the highest three values. Overall mean of 305 day milk

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yield and milk persistency was 8693±1380kg and 46.02±8.95 kg/day, respectively. Estimates of phenotypic ranges were from 3940kg to 12029kg and 38kg to 59kg for both traits, respectively. Genetic and permanent environmental variations in 305 day milk yield and milk persistency were studied within calving ages from 25 to 80 months.

Statistical analysis

The random regression model used in the current study was

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

Where: Y_{ijklm} is the m^{th} observation of the k^{th} cow in the l^{th} lactation, HTD_{il} is the independent fixed effect of i^{th} herd-month-year of calving for l^{th} lactation, n_p is the number of parameters fitted on calving ages function, β_{ilo} is the o^{th} fixed regression coefficient on j^{th} calving age effect in l^{th} lactation, X_{klmo} is the o^{th} dependent trait on calving age, α_{klo} is the O^{th} random regression coefficient of additive genetic effect of k^{th} cow in l^{th} lactation on calving age, ψ_{klo} is the o^{th} random regression coefficient of permanent environmental effect of k^{th} cow in l^{th} lactation on calving age and ε_{ijklm} is the random residual.

The following (co)variance structure was assumed:

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

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 (305-day milk yield and milk persistency) were estimated using the software random regression package, DFREML (Merey, 1998 Version 3ß).

RESULTS AND DISCUSSION

Heritability estimates of 305-day milk yield ($h^2_{MK_{305}}$)

Changes of heritability estimates for 305-day milk yield (305-MY) across age at calving up to 75 months are presented in Figure 1. Estimates of heritability of 305-MYwas varied in narrow ranged from 0.47 to 0.54 with average 0.51±0.013. Rekik (2008) found that, heritability estimates of 305-day milk yield were ranged from 0.23 to 0.42 in dairy cattle under different two environments (Luxembourg and Tunisia).

Findings in Figure 1 show decreasing trend of $h^2_{MK_{305}}$ with progressing calving age. This is may be due to, older population of animals arrived to more additive genetic homogeneity than those during early lactations. Early age at calving (slightly more than 20 months) attained the highest estimates of heritability. Heritabilities of 305-MY were changed in three critical phases across different calving ages. Estimates of $h^2_{MK_{305}}$ within these phases were above the regression line. Around thirty months of calving age occurred the first round for changing $h^2_{MK_{305}}$ in curve shape mode and in narrow range. The other two phases were occurred within older calving ages in curve shape but in wider range than the 1st phase. On the other hand, the highest reduction in heritabilities of 305-day milk yield were occurred in different two phases either above 40th or within 60th to 70th month of calving. It seems that, selection for genetic improving milk production at earlier calving ages could be useful within Saudi Holstein Friesian heifers.

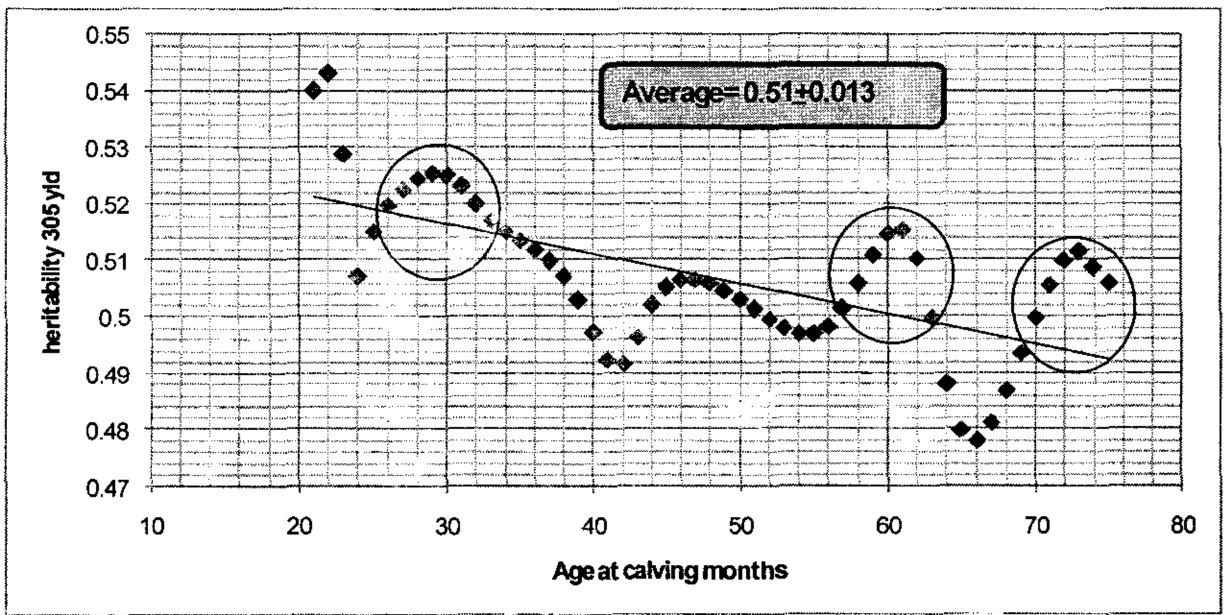

Figure (1): Estimates of heritability of 305-day milk yield for Saudi Holstein Friesian cows across different calving ages using random regression analysis.

Heritability estimates of milk persistency ($h^2_{MK_{Prs}}$)

Estimates of heritability for the milk persistency in Saudi Holstein Friesian cows across different calving ages (months) are illustrated in Figure 2. Estimates of heritability for milk persistency ($h^2_{MK_{Prs}}$) ranging from 0.16 during the middle production life to 0.55 near to the end of production life with overall mean 0.34±0.02. Cole and Null (2009) found that, the highest heritability estimates (0.09 to 0.15) were attained ended for milk persistency among seven evaluated dairy traits using different dairy cattle breeds. They suggested that, milk persistency could be considered as the best economic criteria for improving dairy performance.

Changing estimates of $h^2_{MK_{Prs}}$ are in progressing mode with advancing age at calving. Where $h^2_{MK_{Prs}}$ was 0.31 during the early production life and arrived to 0.55 within the older calving ages. The highest magnitude of $h^2_{MK_{Prs}}$ across different calving ages was occurred within two different phases. The first one was within the first 35 months of calving age (average: 0.29±0.017) and the second one was after 60[th] months of calving (average: 0.53±0.03). On the other hand, the lowest inheritance power of milk persistency was occurred around 50[th] age of calving. Overall mean of $h^2_{MK_{Prs}}$ during the 2[nd] phase was higher by 83% than with the 1[st] phase . It means that, heifer selection for improving persistency must be based on the performance of their dams during late part of production life. Rekik (2008) found that, heritability estimates of milk persistency were ranged from 0.02 to 0.12 in dairy cattle of Luxembourg and Tunisia.

Heritability estimates for milk persistency across the first eight parities and within different five Saudi dairy herds are presented in Table 1. Estimates of heritability for milk persistency across parities were ranging from 0.34 at the 1[st] parity to 0.59 at the 4[th] parity with overall mean 0.47 with 0.08 as standard deviation. While the corresponding range within the five dairy herds were from 0.35 to 0.51 with overall mean 0.44 with standard deviation of 0.08. The current results indicate that possibility for enhancing and prolonging length of deep with highest milk yield are consistent with results obtained for 305-MY.

Changes of inheritance power for milk persistency depending on length of lactation period (days) are illustrated in Figure 3. Overall mean of heritability across different lactation periods was 0.42+0.09. Lactation length between 280 to 330 (around 10 months of lactation) showed the highest and stable mode of heritability estimates for milk persistency (average 0.52). Cows that showed abnormal lactation length (either long or short) are not capable to inherit efficient milk persistency to their progenies. Charudhary *et al.* (2000) found that, positive correlation between persistency and length of lactation period and do not suggest that selection for very long lactation length would result in better milk persistency.

Relationships between repeated measurements of milk persistency:

Additive genetic correlations between repeated measurements of milk persistency in Saudi Holstein Friesian using random regression analysis were presented in Figure 4. Overall means of additive genetic correlations between repeated measurements for milk persistency were 0.41, 0.46, 0.33, 0.62, 0.73 and 0.89. Additive correlation between early and late measures was low (< 0.15). This result indicates that early and late measures of persistency could be considered as different traits. Additive genetic correlations were very high (0.73 to 0.89) between the nearest measures of milk persistency during the late part of productive live (last two lines, Figure 4). This means that, milk persistency had a genetic ability to repeat it self across advanced calving ages especially during late part of productive life. Sharifi *et al.* (2008) found that correlation between repeated measures of lactating persistency trait during short lactation was 0.68.

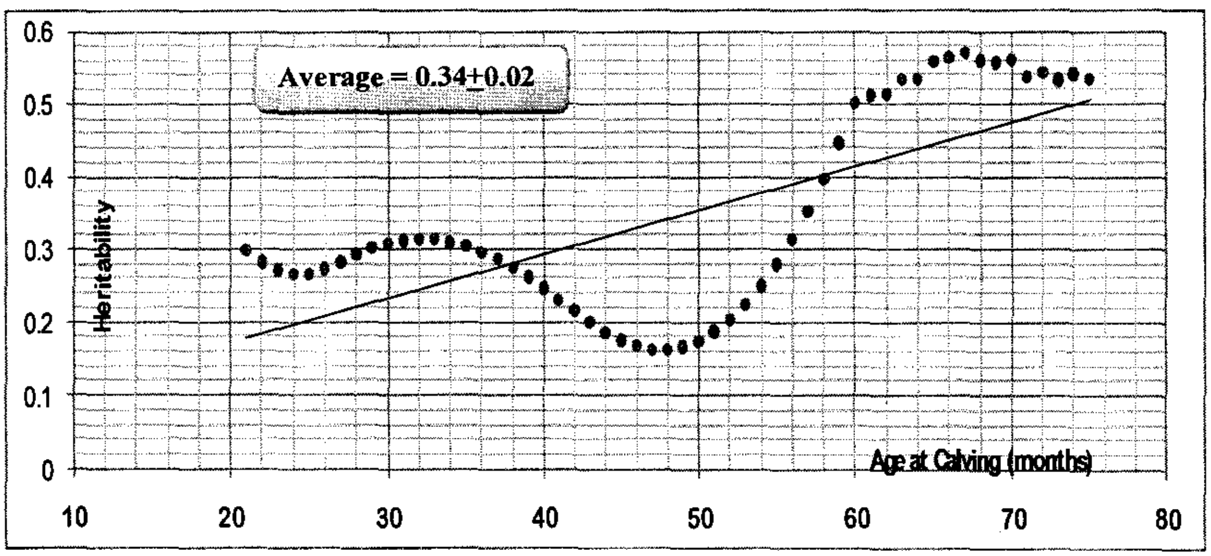

Figure (2): Estimates of heritability of milk persistency in Saudi Holstein Friesian cows across different calving ages using random regression analysis.

Permanent environmental correlations between repeated measurements for milk persistency had a fluctuated fashion no clear trend across most of calving ages. Positive correlations of early measurements with each others were ranging from 0.17 to 0.84. On the other hand, Rc showed a remarkable reduction with direction change of the relationship between measures of milk persistency during the late part of productive time. This might indicate, environmental conditions could play an important role for controlling the relationship between repeated measures of milk persistency. Changes in estimates of correlations between repeated lactational measures of milk persistency using random regression analysis are presented in Figure 5. Overall estimates of both correlation types were Ra: 0.79±0.04, Rc: 0.58±0.05. Estimates of Ra are in slightly progressing mode than Rc with advancing order of lactation. It means that, strongest correlations were observed between measurements of later parties. It seems that milk persistency tend to repeat itself during the last part of productive life.

Relationship between 305-day milk yield and milk persistency:

Changes of additive and permanent environmental relationship between 305-day milk yield and milk persistency in Saudi Holstein Friesian cows across different calving ages are presented in Figure 6.

Additive relationship between 305-day milk yield and milk persistency showed high positive association between 50 to 70 months of calving ages (reached to >0.8). This might indicate, high lactating cows will be characterized by high milk persistency through most part of productive life. On the other hand two negative phases were obtained for the additive relationship between both traits either during early or late part of productive life. The first negative phase was longer and stronger (reached to -0.6) than the later one (-0.2). Findings in Figure 6 show moderate high correlation between both traits at earlier calving ages. Therefore, selection within early first calving heifers for high persistency could be favorable and might be associated with suitable increase in 305-day milk yield. Cole and Null (2009) found that genetic correlations among yield and lactation persistency were low to moderate and ranged from −0.55 to 0.40 across different parities. Hammami, *et al.* (2008) found that, genetic correlations between 305 milk yield and milk persistency were ranged from 0.36 to 0.64 in dairy cattle of Luxembourg and Tunisia. Sharifi *et al.* (2008) found that additive genetic correlation between total milk yield and lactating persistency trait ranged from 0.59 to 0.88 within incomplete and complete lactation periods, respectively.

Table (1): Estimates of heritability and permanent environmental effect within parities and farms for milk persistency in Saudi Holstein Friesian.

Parity	h^2_{Pr}	C^2_{Pr}	farms	h^2_{Pr}	C^2_{Pr}
1	0.34	0.051	1	0.42	0.18
2	0.42	0.69	2	0.51	0.21
3	0.50	0.91	3	0.35	0.11
4	0.59	0.119	4	0.52	0.27
5	0.54	0.165	5	0.38	0.17
6	0.48	0.22	**Average**	**0.44**	**0.19**
7	0.49	0.251	**SD**	**0.08**	**0.06**
8	0.43	0.268			
Average	**0.47**	**0.33**			
SD	**0.08**	**0.30**			

SD: Standard deviation, h^2_{Pr} : lactational heritability, C^2_{Pr} : Lactational permanent environmental effect

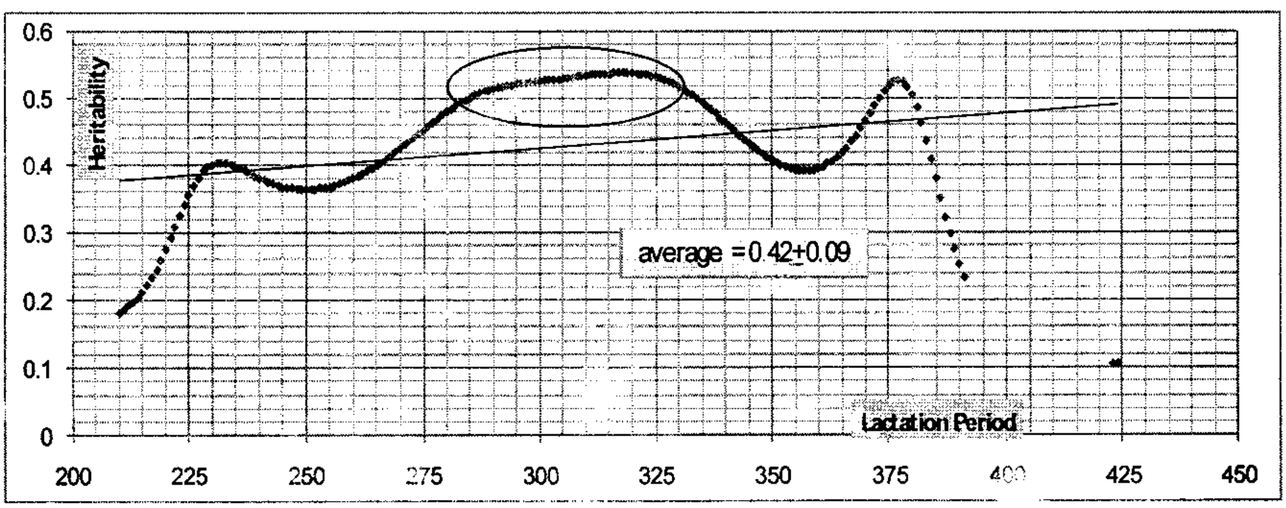

Figure (3): Estimates of heritability for milk persistency across different lactation length in Saudi Holstein Friesian cows using random regression analysis.

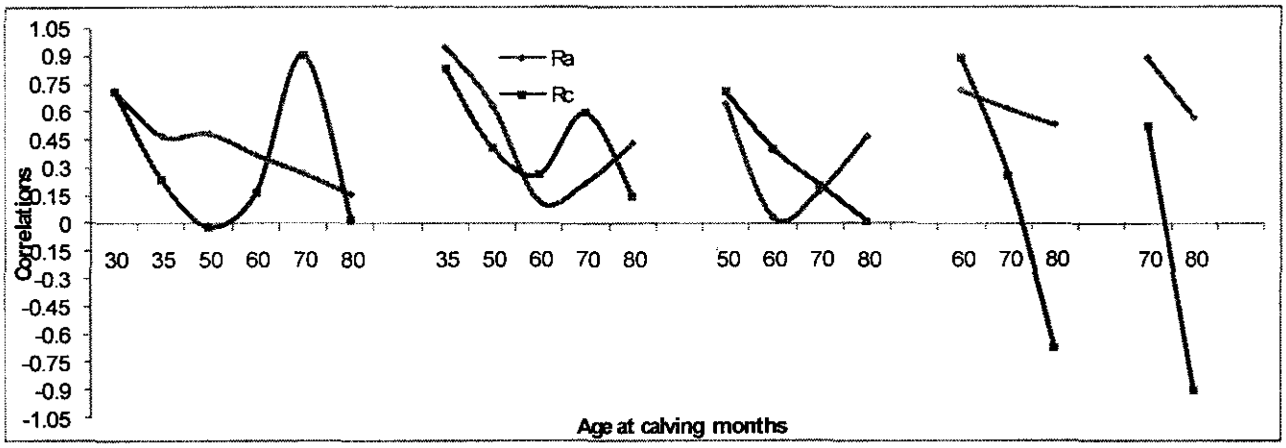

Figure (4): Estimates of additive (Ra) and permanent environmental (Rc) correlations between repeated measurements of milk persistency across different calving ages.

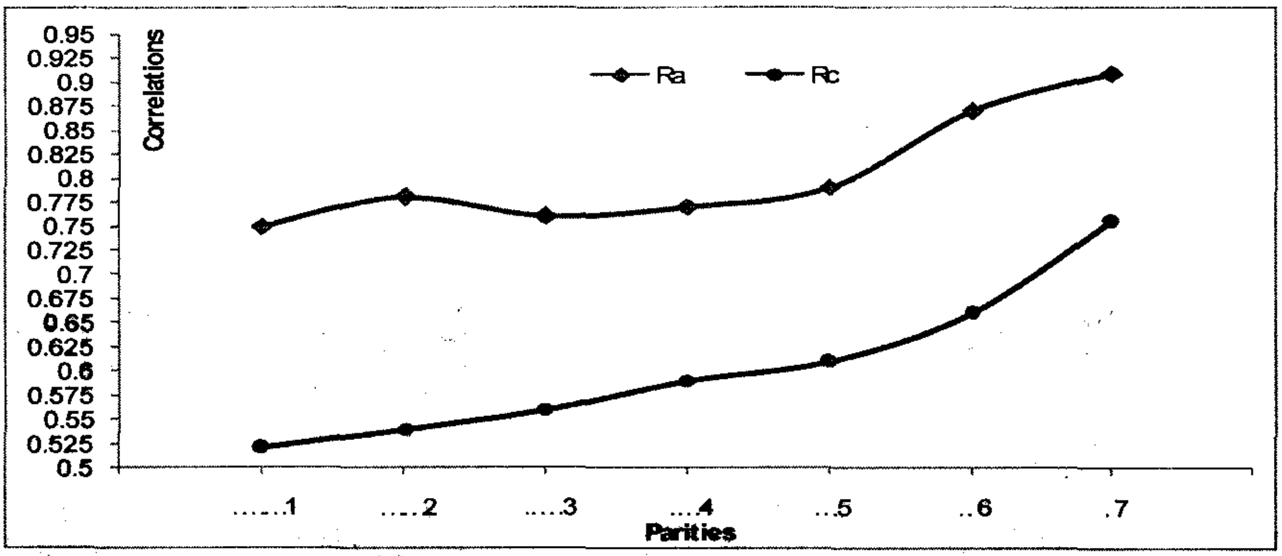

Figure (5): Estimates of additive and permanent environmental correlations between repeated lactational measurements for milk persistency in Saudi Holstein Friesian cows.

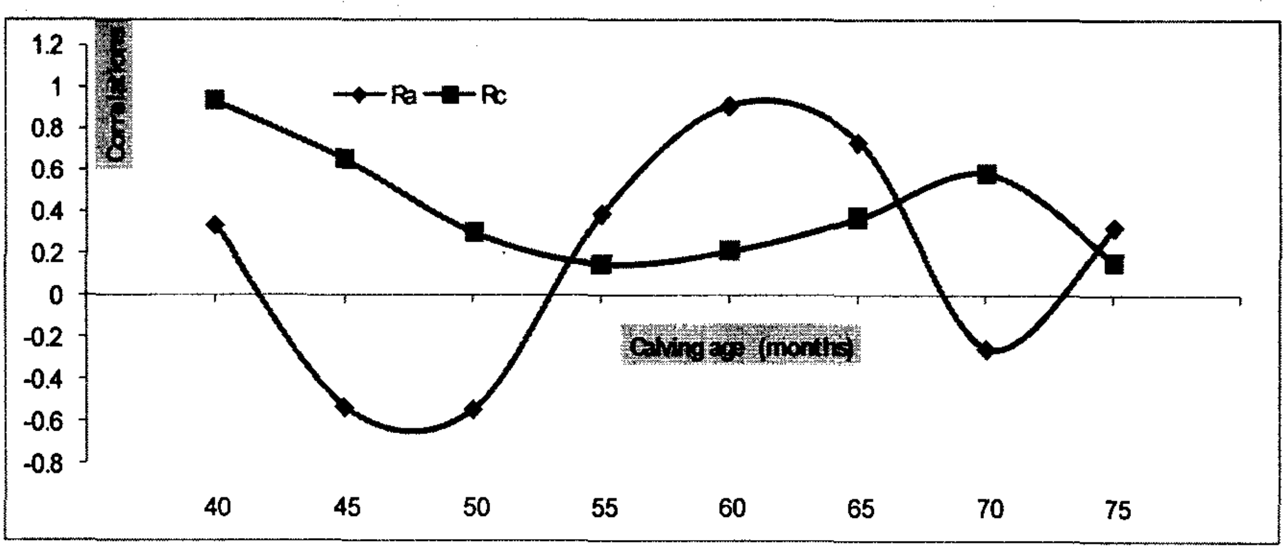

Figure (6): Additive and permanent environmental correlations between 305-day milk yield and milk persistency in Saudi Holstein Friesian cows across different calving ages using random regression analysis.

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