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Use of Random Regressions for Estimating Heritability of Body Scores in Adapted Saudi Holstein Cows

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ABSTRACT

The objective of this study was to estimate the heritability and variance component of Body Condition Score (BCS) of adapted Holstein Friesian in the Kingdom of Saudi Arabia (KSA). The analysis of test day records for dairy cattle and covariance functions of random regression analysis allowed a continuous change of variances and co-variances of BCS on different lactation parts, cow ages and levels of daily milk production. Quadratic Legendre polynomials were used to estimate (co)variances of random effects. A model for analyzing test day records containing both the fixed and random regression coefficients was applied for genetic evaluation of first three lactations. Data was 45,349 BCS observations from calvings between 1989 and 1998 from four different dairy herds in KSA. Each evaluated animal received at least two measurements for BCS representing the random regression coefficients. Three genetic measures of BCS such as cow age, days in milk and the levels of daily milk production were compared. Overall means of BCS across early, mid and late part of production live were 2.8±0.10, 3.3±0.05 and 2.9±0.04, respectively. Based on the random regression solutions, the estimated heritability ranged from 0.19-0.53 for various parts of lactation and 0.02-0.48 across different cow age for BCS. The highest estimate of heritability of BCS based on random regression function of daily milk yield was 0.37 at 10 kg day^{-1}. The corresponding lowest estimate of heritability was 0.26 at 35 kg day^{-1}. The study showed a potential of using random regressions for estimating heritability in adapted animals under different environments.

Key words: Body condition score, heritability, random regression model, test day milk yield

INTRODUCTION

Body condition scoring is an important management practice used by producers as a tool to optimize production, evaluate health and assess nutritional status. This practice helps producers evaluate the amount of fat and muscle carried by the animal. Failure to recognize these animals that are too fat or too thin for their stage of lactation and taking action is expensive for disease treatments, lost milk production and decreased fertility. If body condition scoring is conducted at planned intervals throughout the production cycle, nutrition and management can be altered if needed (Lowman *et al*., 1976). During the production cycle, re-breeding, mid-gestation, parturition and weaning are the most critical times to body condition scoring in animals. The practice of body condition scoring is used mainly to increase economic returns through increased reproductive performance and realize more efficient feed costs (Fox *et al*., 1999). Dairy cows use BCS system ranging from 1.0, a very thin cow with no fat reserves, to 5.0 a severely over-conditioned cow in increment of 0.1 or 0.25. One point of BCS equals 100-140 pounds gain in body weight. Cows should be scored regularly to reflect changes in fat reserves at each stage of lactation. Ideally score for all cows is at the beginning and end of their dry period and at least 4 or 5 times during lactation. Cows should be evaluated based on stage of lactation (days in milk or days dry). Cows should be scored both by looking at and handling the backbone, loin and rump areas. It is critical for producers to identify cows with poor body condition scores early to make important treatment or culling decisions in a timely and responsible manner. Furthermore, BCS levels and changes in BCS are associated with the health and fertility status of the cow (Veerkamp *et al.*, 2000; Collard *et al.*, 2000; Pryce *et al.*, 1999), so BCS is an obvious target for potential selection indices. Selection for yield alone has resulted in cows that have a lower BCS than cows of average genetic merit for production (Pryce *et al.*, 1999). Edmonson *et al.* (1989) reported that the recommended body condition scores at various stages of lactation are 3.0 to 3.5: at calving, 2.5 at breeding 2.5, 3.0-3.5 at late lactation and 3.0-3.5 during dry period.

Using random regression techniques of analysis on field data with BCS measured at different times but only once on each animal, Jones *et al.* (1999) demonstrated that changes in BCS throughout lactation are under genetic control and that BCS has a heritability of around 0.3. De Vries *et al.* (1999) reported a similar analysis with data from the Netherlands. Coffey *et al.* (2001) using data from an experimental herd showed that BCS is relatively easy and cheap to measure on large numbers of daughters via progeny testing and national conformation assessment schemes. Energy balance curves may provide data that could be included in a multi-trait index aimed at improving health and fertility and thereby reducing wastage from the dairy herd for both welfare and environmental reasons.

The objectives of this study were (1) To compute heritability estimates of body condition scores (BCS) across different cow ages or/and lactation orders, (2) To develop different lactation curve parts (different days in milk) and (3) To determine different levels of body condition score and test day milk yield.

MATERIALS AND METHODS

Data consisted of 45,349 Body Condition Score (BCS) observations. Records were considered for the first three lactations of Holstein Friesian cows adapted under Saudi environmental conditions. Body condition score was recorded at least two times per lactation during test day examination with interval between 5 and 365 or more days in milk. 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. Body condition scores observations were 21,211, 16,121 and 8,016 records in the first three parities. Full identification was available for most of the animals. A small part of animals in the currently used data set was partially identified. Five key areas on the body of cows were assessed namely the area between the tail head and pin bones, inside of the pin bones, backbone, hips and depression the hip and pin bones as shown in study of Moran (2005) and Edmonson *et al.* (1989). The system for body condition score ranged from emaciated/very little flesh over the skeleton (score 1) to very fat heavy fat cover (score 8). Only those cows with scores from 1.00-5.00 were described (BCS). Cows with scores of 1.5 or less were very thin and were either severely underfed or suffering from disease or injury. Cows with scores over 5 were considered in the over fat category and were at risk of suffering from metabolic diseases around calving. Scores range from 1 (thin) to 5 (obese); scoring increments may be a tenth, quarter or half points.

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

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

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_{jlois} 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.

The following (co)variance structure was assumed:

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

where, G is the genetic covariance matrix among random regression coefficients and traits, A is the additive numerator relationship matrix, P is permanent environmental covariance matrix among random regression coefficients and traits and E is 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).

RESULTS AND DISCUSSION

Descriptive statistics: Means of BCS across the first three parities are presented in Fig. 1. Overall mean of BCS in this study was 2.92±0.13 with range from 2.81 at the 1st parity to 3.04 at the 3rd parity. Figure 2 shows changes in BCS means across different lactation parts and dry period. Mean of BCS at calving and at the beginning of lactation (3.17) was higher than either mid (2.72) or end of lactation (2.85). Similar trend of changing BCS were observed through individual presentation (Fig. 3). Means of BCS during dry period were similar to those obtained during calving and at the beginning of lactation (Fig. 2). Body condition scores ranging from 2.0-3.0 were more frequent and occurred with the highest percentage (68.45%) for the current data set. Body condition scores less than 1.75 and greater than 4.5 were in small values and contributed only up to 2.99% (Fig. 4).

Distribution of means of BCS across different cow ages was illustrated in Fig. 5. Overall means of BCS across early, mid and late part of production live were 2.8±0.10, 3.3±0.05 and 2.9±0.04, respectively. Means of BCS increased gradually with progressing cow age from >2.5 at 22 months

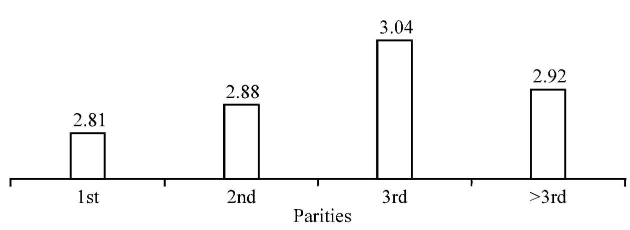

Fig. 1: Distribution of means of body condition scores across different parities

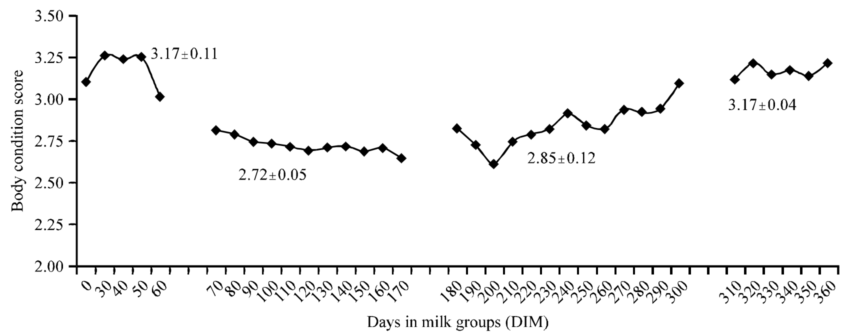

Fig. 2: Distribution of means of body condition scores across different days in milk groups

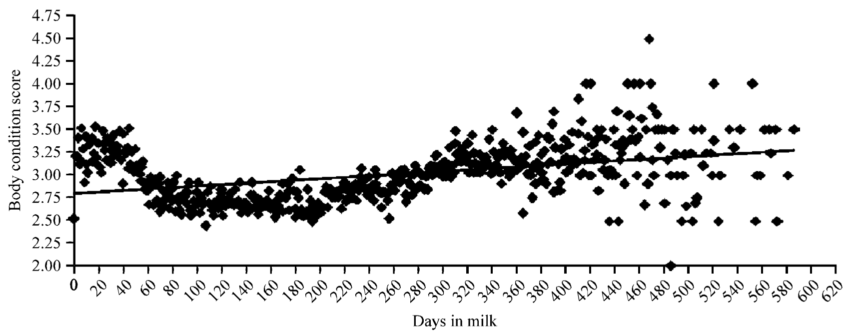

Fig. 3: Distribution of body condition scores across different days in milk

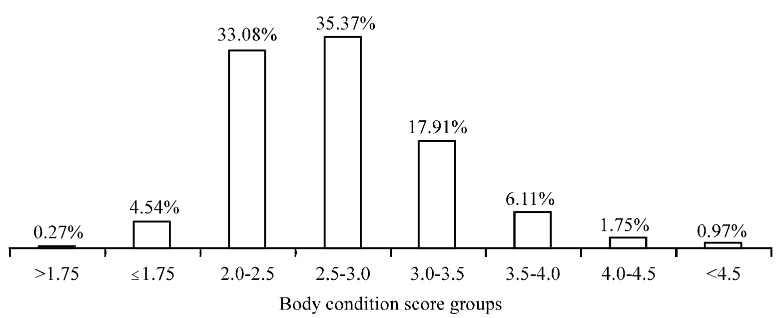

Fig. 4: Distribution of body condition scores

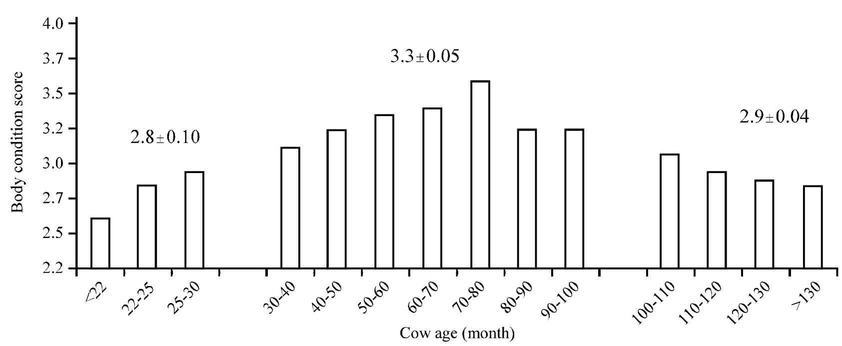

Fig. 5: Distributions of body condition scores across different cow age groups

of age to >3.5 at 70-80 months of cow age and then decreased toward the end of productive life. The current results partially agree with those reported by Jones *et al.* (1999), Pryce *et al.* (2001) and Berry *et al.* (2002). Lactational heritability estimates: Estimates of heritability using random regression analysis of BCS in the first three lactations are given in Table 1, along with their standard errors. Overall estimate of heritability for BCS was 0.19±0.04. There were 4 different estimates of heritability for BCS from random regression analysis across more than the first three lactations and varied from 0.10-0.32 across different lactations. Estimates of h^2 were changed in curve-shape mode. Among more than the first three lactations, older lactations (>the 3rd lactation) BCS started their performance with the lowest inheritance power (1st Pr: 0.15 and 2nd Pr: 0.10). The heritability estimates were significant for BCS, with standard error being less than or equal to 0.12. No permanent environmental variance existed for BCS with random regression analysis. It appears that, genetic improvement could be the principal role for enhancing the performance of BCS. Zavadilova *et al.* (2005) reported that additive genetic variances using random regression analysis increased with parity and heritability estimates increased in turn, especially from the 2nd to the 3rd lactation.

Heritabilities of BCS across different cow ages: Changes of heritability estimates of Holstein Friesian body condition scores across different cow ages were plotted in Fig. 6. Estimates of h^2 ranged from 0.02-0.48 with overall mean equal to 0.23±0.02 across more than 100 months of cow age. Variations in estimates of h^2 were very high during early cow age which decreased gradually with progressing age. The highest estimates of h-BCS^2 were attained around 30th month of cow age. It means that early genetic selection for improving BCS could be possible. The general linear change in estimates of h^2 mode tended to decrease toward old age cows. Estimates of permanent environmental effect were null and ranged from 0.01-0.06. It means that the contribution of environmental conditions in improving BCS could be negligible.

Table 1: Estimates of heritability (h^2), additive (σ^2a), permanent environmental (σ^2c) and phenotypic (σ^2p) variance of body condition score across different parities (Pr)

Pr	h^2	σ^2a	σ^2c	C^2	σ^2p
1	0.15±0.03	0.059	0.023	0.059	0.390
2	0.10±0.00	0.034	0.002	0.006	0.343
3	0.32±0.11	0.140	0.004	0.009	0.456
>3	0.19±0.07	0.074	0.005	0.013	0.387

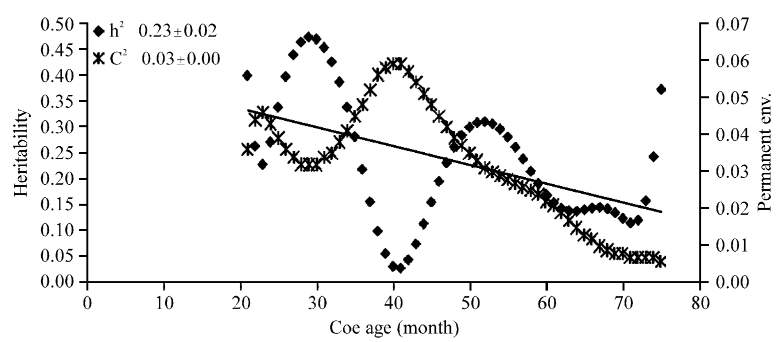

Fig. 6: Heritability and permanent environmental estimates of body condition score of Holstein Friesian across different ages

Estimates h^2 across different DIM: Changes in estimates of h^2 using random regression analysis across different stages of lactation are plotted in Fig. 7 using pooled lactation data set. Estimates of BCS heritability increased after calving with progressing days in milk until 240 DIM. Interval from 120 - 320 days in milk involved the highest estimates of h-BCS^2 which was more than 0.50. It appears that BCS additive genetic variations were very high during the late part of lactation. It means that genetic selection for improving BCS were available during the late 2/3 part of lactation. The general linear trend of h^2 decreased toward trajectory end by including cows with long lactations (>305 DIM). Estimates h-BCS^2 during the early part of lactation are not low, it ranged from 0.30 to <0.50 during the first three months of lactation. It suggests that early genetic selection based on BCS could be possible. Coffey *et al.* (2003) found that genetic variance for BCS rose abruptly towards the end of lactation. This could be the effect of increasing the heritability in a similar fashion. At the minimum point of the trajectory, the heritability for BCS was about 0.25. The estimates obtained in the current study are similar to those reported by Jones *et al.* (1999) and Veerkamp *et al.* (2000). The current results showed that environmental conditions did not play any significant role in improving the body condition score during 305 days lactation.

Heritabilities of BCS across milk production levels: Changes of h^2 across different test day milk yield levels are presented in Fig. 8. Overall estimate of h^2 across different levels was 0.28±0.01. Estimates of h^2 decreased from 0.38-0.26 with progressing level of daily milk production from 10 kg to 35-45 kg day^{-1}. Estimates of h^2 increased slightly from 50 kg day^{-1} in curve-shape mode towards the highest daily production (65 kg). Estimates of h^2 across production levels from 25-50 kg day^{-1} showed little changes (around 0.25). Genetic selection for improving BCS could be possible within the lowest (10 to 20 kg day^{-1}) levels of daily production.

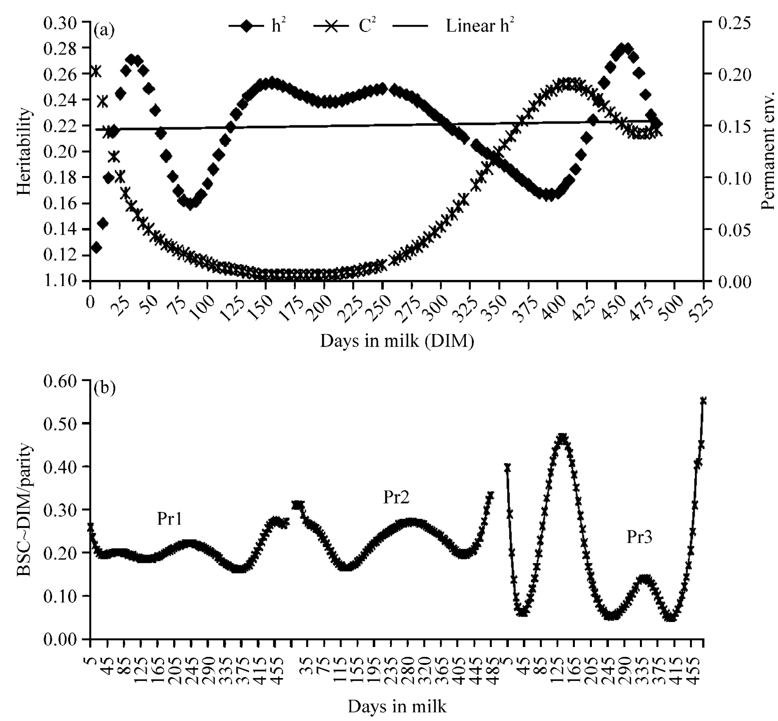

Fig. 7(a-b): (a) Body condition score heritability estimates across days in milk within pooled and (b) Separate lactations of Holstein Friesian using random regression animal model

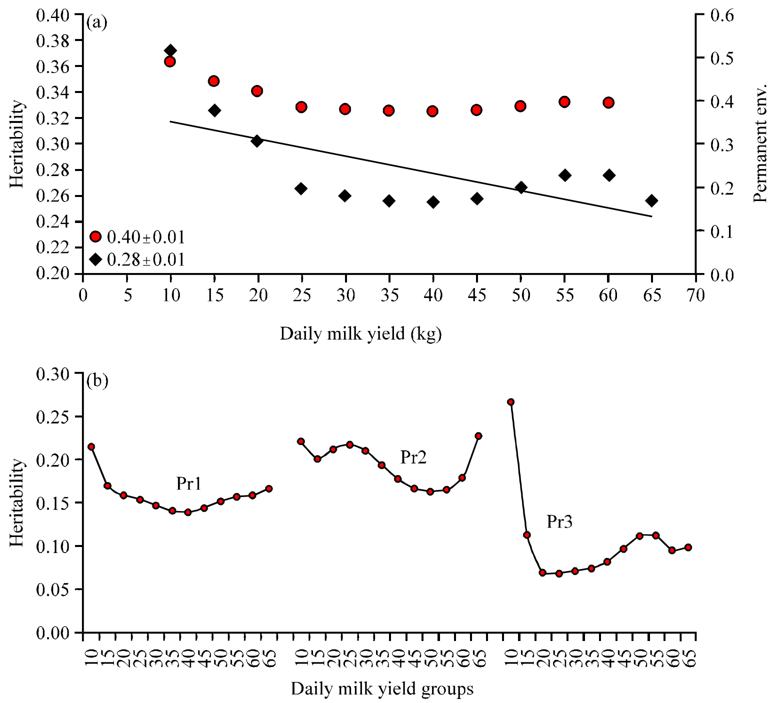

Fig. 8(a-b): Estimates of heritability at different levels of daily milk production using (a) Pooled and (b) Separate parities data sets

Changes of h^2 across different levels of daily milk production within the first three parities separately are illustrated in Fig. 8. Estimates of h^2 ranged from 0.13-0.21, 0.13-0.21 and 0.07-0.27 across different levels of daily milk production within the first three lactations. Variability was substantial among estimates h-BCS^2 within all parities. Hence, the shapes of heritability curve for BCS was also variable. On the other hand, the highest h^2 appeared at the lowest milk production level for all parities except the 2nd parity. For all three lactations, the variability was the lowest in the 1st followed by either the 2nd or the 3rd lactation which corresponded to similar h^2 changing mode. In general, for all three lactations, the linear trend decreased with progressing level of milk production. It means that ability for improving body condition scores was high for the lowest production groups.

CONCLUSIONS

Three genetic measures of BCS such as cow age, days in milk and the levels of daily milk production were compared. Overall mean of Body Condition Score (BCS) was 2.92+0.13 with range from 2.81 at the 1st parity to 3.04 at the 3rd parity. Mean of BCS at calving and at the beginning of lactation (3.17) was higher than either mid (2.72) or end of lactation (2.85). However, means of BCS across early, mid and late part of production live were 2.8±0.10, 3.3±0.05 and 2.9±0.04, respectively. Based on the random regression solutions, the estimated heritability ranged from 0.19-0.53 for various parts of lactation and 0.02-0.48 across different cow age for BCS. The highest estimate of heritability of BCS based on random regression function of daily milk yield was 0.37 at 10 kg day^{-1}. The corresponding lowest estimate of heritability was 0.26 at 35 kg day^{-1}. The study showed a potential of using random regressions for estimating heritability in adapted animals under different environments.

REFERENCES

Berry, D.P., F. Buckley, P. Dillon, R.D. Evans, M. Rath and R.F. Veerkamp, 2002. Genetic parameters for level and change of body condition score and body weight in dairy cows. J. Dairy Sci., 85: 2030-2039.

Coffey, M.P., G. Simm, W.G. Hill and S. Brotherstone, 2003. Genetic evaluations of dairy bulls for daughter energy balance profiles using linear type scores and body condition score analyzed using random regression. J. Dairy Sci., 86: 2205-2212.

Coffey, M.P., G.C. Emmans and S. Brotherstone, 2001. Genetic evaluation of dairy bulls for energy balance traits using random regression. Anim. Sci., 73: 29-40.

Collard, B.L., P.J. Boettcher, J.C.M. Dekkers, D. Petitclerc and L.R. Schaeffer, 2000. Relationships between energy balance and health traits of dairy cattle in early lactation. J. Dairy Sci., 83: 2683-2690.

De Vries, M.J., S. Van Der Beek, L.M.T.E. Kaal-Lansbergen, W. Ouweltjes and J.B.M. Wilmink, 1999. Modeling of energy balance in early lactation and the effect of energy deficits in early lactation on first detected estrus postpartum in dairy cows. J. Dairy Sci., 82: 1927-1934.

Edmonson, A.J., I.J. Lean, L.D. Weaver, T. Farver and G. Webster, 1989. A body condition scoring chart for Holstein dairy cows. J. Dairy Sci., 72: 68-78.

Fox, D.G., M.E. Van Amburgh and T.P. Tylutki, 1999. Predicting requirements for growth, maturity and body reserves in dairy cattle. J. Dairy Sci., 82: 1968-1977.

Jones, H.E., I.M.S. White and S. Brotherstone, 1999. Genetic evaluation of Holstein Friesian sires for daughter condition-score changes using a random regression model. Anim. Sci., 68: 467-476.

Lowman, B.G., N.A. Scott, S.H. Somerville, 1976. Condition Scoring of Cattle. Edinburgh School of Agriculture, New York, ISBN-13: 9780902164239, pp: 31.

Meyer, K., 1998. DXMRR-A program to estimate covariance functions for longitudinal data by restricted maximum likelihood. Proceedings of the 6th World Congress on Genetics Applied to Livestock Production, January 12-16, 1998, Armidale, NSW, Australia, pp: 465-466.

Moran, J., 2005. New system of scoring the body condition of dairy stock. http://www.landlinks.com.au/

Pryce, J. E., B.L. Nielsen, R.F. Veerkamp and G. Simm, 1999. Genotype and feeding system effects and interactions for health and fertility in dairy cattle. Livest. Prod. Sci., 57: 193-201.

Pryce, J.E., M.P. Coffey and G. Simm, 2001. The relationship between body condition score and reproductive performance. J. Dairy Sci., 84: 1508-1515.

Veerkamp, R.F., J.K. Oldenbroek, H J. van der Gaast and J.H.J. van der Werf, 2000. Genetic correlation between days until start of luteal activity and milk yield, energy balance and live weights. J. Dairy Sci., 83: 577-583.

Zavadilova, L., J. Jamrozik and L.R. Schaeffer, 2005. Genetic parameters for test-day model with random regressions for production traits of Czech Holstein cattle. Czech J. Anim. Sci., 50: 142-154.