The Journal of Animal & Plant Sciences, 23(2): 2013, Page: 345-349
ISSN: 1018-7081

ESTIMATION OF GENETIC PARAMETERS AND BREEDING VALUES FOR DAIRY CATTLE USING TEST-DAY MILK YIELD RECORDS

A. Kaygisiz

Kahramanmaras Sutcu Imam University, Faculty of Agriculture, Department of Animal Science, Kahramanmaraş-Türkiye
Corresponding Author: alikaygisiz@ksu.edu.tr

ABSTRACT

The aim of this study was to estimate genetic parameters and breeding values for 305-d and test-days (TD) milk yields, and to compare the obtained results. For this aim, the data were collected during the years of 1989 and 2007 for 11200 lactation records of Holstein cattle reared at Ceylanpinar State Farm in the Southern East Region of Türkiye. The 305-d milk yield of each animal was calculated using the Test Interval Method (TIM). Additive genetic, residual and permanent environmental variances, heritabilities and breeding values for 305-d and TD milk yields were estimated by using the REML method on the basis of animal models. Heritability of test day milk yield (0.15) was lower than the heritability of 305-d milk yield (0.20). Pearson, Spearman and Kendall correlation coefficients between breeding values for test day and 305-d milk yield were estimated as: 0.90, 0.90 and 0.74 ($P<0.01$) for bulls and 0.78, 0.92 and 0.76 ($P<0.01$) for cows, respectively. Present results reflected that use of test day milk yields could be suggested to estimate 305-d milk yield for the genetic evaluation of dairy cows. Furthermore, use of TD milk yield for genetic evaluations permits researchers to gain more advantages.

Keywords: Holstein Cattle, 305-d Milk Yield, Test Day Yield, Genetic Parameters, Breeding Value

INTRODUCTION

In dairy breeding, selection for the milk yield has been mostly made on the basis of 305-d milk yield (Ptak and Schaeffer, 1993; Bilal *et al.*, 2008; Seyedsharifi *et al.,* 2008; Bilal and Khan, 2009). An alternative approach for genetic evaluation is to use directly test-day (**TD**) milk yields (Kaya *et al.*, 2003; Tailor and Singh, 2011). The TD models are used to analyze individual TD records of cows instead of 305-d milk yields (Pool and Meuwissen, 1999). In this context, the records from single and early TD provided researchers to make earlier selection decision (Bilal and Khan, 2009). The main objectives of selection on TD were to reduce recording costs and to increase accuracy of genetic evaluation (Nigm *et al.,* 2003).

TD models (i) evaluate individual TD records of cows instead of 305-d milk yields, (ii) are also animal models that focus on each TD observation rather than total lactation data (Powell and Norman, 2006; Bilal and Khan, 2009), (iii) are the statistical procedure that includes all genetic and environmental effects directly on a TD basis (Ptak and Schaeffer, 1993). Use of TD milk yield depends on the relative amount of genetic variation during the lactation (Swalve 1995; Bilal and Khan, 2009).

Incomplete lactations are projected from the available TD records to 305-d milk yields with the requirement that the cow had been milked for a minimum number of days or had at least two TD records (Bilal and Khan, 2009). The accuracy of 305-d measures can vary depending on the number of test and the procedures which are used (Swalve, 1995). The projection factors assume a standard shape of the lactation curve for a cow of a particular breed and lactation number (Bilal and Khan, 2009).

Using TD data allows one to obtain information from lactations with long intervals between milk recordings because estimation of yields for unrecorded intervals would not be required (Wiggans and Goddard, 1997).

In shortly, TD models; (i) improve the accuracy of genetic evaluation, (ii) provide more effectively modeling in comparison with other models, (iii) consider all genetic and environmental effects directly on a TD basis, (iv) mean that extending of part lactation is no more needed, (v) mean that cost of milk recording may also be reduced by having longer intervals between milk recording and collecting less frequent amount of milk samples (Ptak and Schaeffer, 1993; Swalve, 1995; Kaya *et al.,* 2003; Bilal and Khan, 2009). However, a TD model can not overcome the loss regarding accuracy from using fewer TD or inaccuracies of recording (Wiggans and Goddard, 1997).

In the most of studies, the sires and cows have been evaluated genetically on the basis of 305-day-milk yield, comprising monthly TD records during lactation with the aim of improving the selection strategies for genetic improvement in dairy science (Çilek *et. al.,* 2008; Rehman and Khan, 2009; Yilmaz *et.al.,* 2011). Previously, correlations between estimated breeding values (EBVs) for TD and 305-d milk yields ranged from 0.87 to 0.97 in the Ptak and Schaeffer (1993), from 0.88 to 0.96 by Swalve (1995), from 0.87 to 0.92 by Reents *et* *al.* (1997), from 0.86 to 0.99 by Kaya *et al.* (2003), from 0.93 to 0.97 by Seyedsharifi *et al.*(2008), from 0.66 to 0.86 by Çilek and Kaygisiz (2008), from 0.23 to 0.95 and 0.31 to 0.93 by Dalal *et al.*(1999), from 0.85 to 0.94 by Ledic *et al.* (2002), and from 0.923 to 0.927 by Khan *et. al.* (2008).

Several researchers reported that a comparison of both sets of breeding values indicated only minor changes in sire rank (Swalve, 1995; Dalal *et al.,* 1999; Schaeffer *et al.,* 2000; Kaya *et al.*, 2003; Seyedsharifi *et al.*, 2008; Khan *et al.*, 2008; Çilek and Kaygisiz, 2008; Bilal and Khan, 2009). As the differences between ranking of daughters sired by bulls for EBVs according to TD and 305-d yields are not found, TD milk yield can be used especially for genetic evaluation of bulls and cows.

The purpose of the present study was to determine genetic parameters for 305-d and TD milk yields and to investigate procedures of breeding value estimation for Holstein cattle reared at Ceylanpinar State farm, in Sanlıurfa province of the Southern East Region of Türkiye.

MATERIALS AND METHODS

In the current study, lactation records on TD milk yields between 1989-2007 years of Holstein cows reared on Ceylanpinar State Farm were provided. Descriptive information about the data which were used in the study is presented in *Table 1*.

Breeding cows have been provided from the breeding herd. Artificial insemination for cows was preferred. The 305-d milk yield of each animal was calculated using the Test Interval Method (TIM) as described by ICAR (ICAR, 2011).

$$305\text{days}=\mathrm{I}_0*\mathrm{M}_1+I_1\frac{M_1+M_2}{2}+I_2\frac{M_2+M_3}{2}+..I_{n-1}\frac{M_{n-1}+M_n}{2}+I_n*M_n$$

Table 1. Summary information of the test-day and 305-d lactation yield data sets

Data	N
Total lactation records	11200
Total TD records	109662
TD records per lactation	9.79
Sires	239
Cows	4195
Cow number per sire	17.55
Year	19
Season	4

Where; M_1, M_2, …, M_n – test day milk yield, kg,
I_1, I_2, ,,,, I_{n-1} – the intervals between recording dates, days;
I_0 – the interval between the lactation period start date and the first recording date, days;
I_n – the interval between the last recording date and the 305th lactation day.

Variance components (additive genetic, residual, and permanent environmental variances), heritability, repeatability and breeding values for 305-d and TD milk yields were estimated by the REML method using animal models with a DFREML 3.0 program (Meyer, 1997). The linear models used were as follows:
For 305-d milk yield,

$$\mathrm{Y}_{ijkl}=\text{«}+c_i+d_k+a_j+pe_j+b_1X_{1ijk}+b_2X_{2ijk}+b_3X_{3ijk}+e_{ijkl}$$

Y_{ijkl} = 305-d milk yield, μ = population mean, c_i = i. effect of calving year, d_k = k. effect of calving season, a_j = j. animal's random additive genetic effect, pe_j = j. effect of random permanent of the cow during lactation, X_{1ijk} = age of calving, as a covariable (linear), X_{2ijk} = age of calving, as a covariable (quadratic), X_{3ijk} = days in milk (DIM) TD, as a covariable, e_{ijkl} = random, residual effects.

For TD records,

$$\mathrm{Y}_{ijkl}=\text{«}+c_i+d_k+a_j+pe_j+b_1X_{1ijk}+b_2X_{2ijk}+b_3X_{3ijk}+b_4X_{4ijk}+b_5X_{5ijk}+b_6X_{6ijk}+e_{ijkl}$$

Y_{ijkl} = milk yield record from a single TD, μ = population mean, c_i = i. effect of calving year, d_k = k. effect of calving season, a_j = j. animal's random additive genetic effect , P_{ej} = j. effect of random permanent of the cow during lactation, X_{1ijk} = age of calving, as a covariable (linear), X_{2ijk} = age of calving, as a covariable (quadratic), X_{3ijk} = DIM / c, as a covariable, where c is a constant set to 305-d (Ptak and Schaffer, 1993), X_{4ijk} = $(\mathrm{DIM} / c)^2$, as a covariable, X_{5ijk} = ln (c / DIM), as a covariable, X_{6ijk} = $(\ln (c / \mathrm{DIM}))^2$, as a covariable, e_{ijkl} = random error, residual effects.

Correlations between breeding value of 305-d and test day milk yields were estimated using CORR procedure of SAS statistical program (Orhan *et al.*, 2004).

RESULTS

In the present study, calving year and calving season significantly influenced 305-d milk yield ($P<0.01$). Also, significant linear (17.77±2.37 kg) and quadratic (-0.20±0.02 kg) effects of age at calving on 305-d milk yield were found ($P<0.01$).

Table 2 presents phenotypic means and standard errors for 305-d and TD milk yields and DIM for the first 10 TD. Estimates of variance components, heritability and the relative portion of permanent environment variance (PE) to total variance for TD and 305-d milk yields are depicted in Table 3.

The heritabilities of 305-d and TD milk yields were 0.20 and 0.15, respectively. These results illustrated that heritability estimate of TD milk yield was lower than the estimate of 305-d milk yield. The relative portion of permanent environmental variance to total variance for 305-d and TD milk yields were determined to be 0.08 and 0.09 respectively.

Table 2. Phenotypic means and standard errors for 305-d and TD milk yields

Traits	Number of Records	DIM		Milk Yield (kg)	
		$\bar{X}$	S.E	$\bar{X}$	S.E
305-d	11200	-	-	5319.91	12.03
TD 1	11200	17.69	0.082	21.71	0.056
TD 2	11200	48.10	0.083	22.61	0.058
TD 3	11200	78.57	0.083	21.98	0.056
TD 4	11200	108.94	0.083	20.94	0.054
TD 5	11200	139.42	0.081	19.86	0.054
TD 6	11108	169.71	0.083	18.58	0.056
TD 7	11034	200.23	0.083	17.31	0.057
TD 8	10908	230.90	0.083	15.77	0.058
TD 9	10766	260.97	0.083	13.95	0.058
TD 10	9846	291.56	0.083	11.22	0.062

Table 3. Estimates of variance components, heritability and repeatability for 305-d and TD milk yields

	σ^2_A	σ^2_E	σ^2_{PE}	σ^2_P	h^2	PE	r
305-d	285658	1030383	112250	1428291	0.20	0.08	0.28
TD	6.15	30.79	3.65	198	0.15	0.09	0.24

Pearson product-moment, Spearman rank and Kendall correlations between breeding values for 305-d and TD milk yields for cows and sires with different numbers of daughters are depicted in *Table 4.*

The estimated breeding values for 305-d milk yield were closely correlated with the estimated breeding values for TD milk yield. Pearson correlations between the estimated breeding values for 305-d and TD milk yields for cows and sires were notably high with 0.78 ($P<0.01$) and 0.90 ($P<0.01$) respectively. Especially, within sires, the correlations increased as number of daughters per sire increased on account of the improved accuracy.

Shifts in rank for the various top listed sires and cows were determined in order to present changes in both the ranking. The shifts in ranking of first 5, 10, 25, 50, 75 100 cows and first 5, 10, 25, 50, 75, 100 sires are illustrated in *Table 5*.

When only the first 5 cows were considered, there were three cows on both lists.

Table 4. Correlations between estimated breeding values for 305-d and TD milk yields

Traits	N	Pearson	Spearman	Kendall
All cows	4195	0.783^{**}	0.916^{**}	0.760^{**}
All sires	239	0.904^{**}	0.901^{**}	0.744^{**}
Sires with ≥ 2 daughters	187	0.942^{**}	0.941^{**}	0.797^{**}
Sires with ≥ 5 daughters	146	0.944^{**}	0.944^{**}	0.807^{**}
Sires with ≥ 10 daughters	115	0.947^{**}	0.941^{**}	0.800^{**}
Sires with ≥ 15 daughters	96	0.950^{**}	0.941^{**}	0.803^{**}
Sires with ≥ 20 daughters	80	0.945^{**}	0.938^{**}	0.794^{**}
Sires with ≥ 35 daughters	42	0.949^{**}	0.933^{**}	0.800^{**}
Sires with ≥ 50 daughters	18	0.950^{**}	0.917^{**}	0.778^{**}
Sires with ≥ 75 daughters	6	0.972^{**}	0.943^{*}	0.867^{**}
Sires with ≥ 85 daughters	3	0.997^{**}	1.00^{**}	1.00^{**}

$^{*}P<0.05$, $^{**}P<0.01$

Table 5. Shifts in rank of cows and sires by 305-day milk yield EBVs compared with ranking by TD milk yield EBVs

Cows			Sires (All)			Sires (with ≥ 5 daughters)		
percentage of cows on both lists			percentage of sires on both lists			percentage of sires on both lists		
Cows(first 5)	3	% 60	Sires (first 5)	4	% 80	Sires (first 5)	3	% 60
Cows(first 10)	5	% 50	Sires (first 10)	6	% 60	Sires (first 10)	8	% 80
Cows(first 25)	13	% 52	Sires (first 25)	18	% 72	Sires (first 25)	20	% 80
Cows(first 50)	24	% 48	Sires (first 50)	45	% 90	Sires (first 50)	43	% 86
Cows(first 75)	39	% 52	Sires (first 75)	63	% 90	Sires (first 75)	69	% 92
Cows(first 100)	59	% 59	Sires (first 100)	88	% 88	Sires (first 100)	93	% 93

Similarly, when only the first 10 cows were taken into consideration, five cows were available on both lists. For the various top lists of cows, more than 48% of the cows were found in both lists. In view of sires with 5 and more than 5 daughters, three sires appeared in both lists.

When the first 10, 25, 50, 75 and 100 bulls are considered, the number of bulls lists were 80%, 80%, 86%, 92% and 93%, respectively. For all the sires, regardless of the number of daughters, the number of sires on both lists ranged from 60 to 90%.

DISCUSSION

In the present study, the heritability of 0.20 for 305-d milk yield which was estimated was similar to the report of Akman and Kumlu (2004), while the present estimate was lower than the values reported by several researchers in different publications (Kaya *et al.*, 2003; Fereira *et al.,* 2003; Shadparvar and Yazdanhenas, 2005). However, the present estimate (0.20) was remarkably higher than the estimates reported by Saatci *et al.* (2000), Ulutaş *et al.* (2004), Seyedsharifi *et al.* (2009) and Khan *et al.* (2008).

An estimate of 0.17 for the same herd earlier by Ertugrul *et al.,* (2002) was very close to the present estimate, whereas Unalan and Cebeci (2004) reported heritabilities of 0.297, 0.369 and 0.359 for the first, second, and third lactations, which were lower than the estimate under the investigation. In the present case, the available data may lead to the differences in the heritability estimates and model number because in the limited population, Unalan and Cebeci (2004) estimated these heritabilities for all the parities. Additionally, it was observed that the heritability estimates changed as result of increasing the population size and differentiating genetic structure of the population.

The heritability estimate of the milk yield under the TD model was lower compared to the corresponding estimate for 305-d milk yield. These results were in agreement with the results of Kaya *et al.* (2003) and Swalve (1995).

The estimation of the relative portion of the permanent environmental variance to the total variance of the TD models was found as 0.09, which was very similar to the estimation of Cilek and Kaygisiz (2008) with 0.10, but it was lower as compared with Kaya *et al.* (2003) and Swalve (1995).

Pearson correlations were noted between the breeding values for 305-d and TD milk yields for cows and sires. Pearson correlations were 0.78 ($P< 0.01$) for cows and 0.90 ($P < 0.01$) for sires. These present results obtained in the study were in agreement with previous results reported by Ptak and Schaeffer (1993), Kaya *et al.* (2003), Çilek and Kaygisiz (2008), and Seyedsharifi *et al.* (2008). Among the sires, these correlations increased as the number of daughters per sire increased.

In addition, Spearman correlations were determined between the breeding values for 305-d and TD milk yields for cows and sires. In the current study, Spearman correlations were 0.916 ($P < 0.01$) for cows and 0.90 ($P < 0.01$) for sires. In a similar way, Kendall correlations were calculated between the breeding values for 305-d and TD milk yields for cows and sires. Kendall correlations were 0.76 ($P < 0.01$) for cows and 0.74 ($P < 0.01$) for sires. These present correlations were higher than the correlations given by Çilek and Kaygisiz (2008), whereas the present correlations were lower compared to the correlations of Ptak and Schaeffer (1993), Kaya *et al.* (2003) and Seyedsharifi *et al.* (2008), while these correlations were similar to those reported by Khan *et al.* (2008). When shifts in ranking for cows and sires ranked by their 305-d s and TD milk yield in estimating breeding values were taken into consideration, the percentage of cows and sires available in both lists obtained for this study were similar to the findings of Swalve (1995), Kaya *et al.* (1993), and Khan *et al.* (2008).

Ranking changes belonging to bulls and cows in terms of breeding values estimated for 305-d and TD milk yield models were in line with the reported results by Swalve (1995), Kaya *et al.* (2003), Khan *et al.*, (2008).

All the correlations, (Pearson, Spearman, and Kendall) between the breeding values for 305-d and TD milk yields for cows and sires were significantly higher. The ranking of sires was influenced less than the ranking of cows when the TD model was used to estimate the breeding value.

In conclusion, use of TD milk yields offered a better modeling opportunity and more accurate in genetic evaluation. Also, TD milk yields in this farm should be taken into consideration for selection of the cows for milk yield in respect of early culling to select cows from milk yield.

Acknowledgments: The author wish to thank Dr. Ecevit EYDURAN and Prof.Dr. Yusuf VANLI for his valuable suggestions. The study was supported by the Scientific and Technological Research Council of Turkey (TUBİTAK, Project No. 108 O 272)

REFERENCES

Akman, N and S. Kumlu (2004). Genetic and phenotypic parameters for 305-d milk yield of Turkish Holstein population. *Tarım Bilim Derg*, 10(3): 281-286.

Bilal, G., M. S. Khan., I. R. Bajwa and M. Shafiq (2008). Genetic Control of Test-Day Milk Yield in Sahiwal Cattle. *Pakistan Vet J,* 28(1): 21-24.

Bilal, G and M. S Khan (2009). Use of Test-Day Milk Yield for Genetic Evaluation in Dairy Cattle: A Review. *Pakistan Vet J*, 29(1): 35-41.

Canavesi, F., S. Biffani., G. Bramante and R. Finocchiaro (2009). Improving the stability of test day model evaluation for production traits in the Italian Holstein. *Ital J Anim Sci*, 8(Suppl.2) : 39-41.

Çilek, S., H. Orhan, A. Kaygisiz and E. H. Sahin (2008). Estimation of Breeding Values of Anatolian Population of Simmental cows using monthly test day milk yield. Arch. Zootech., 11: 79–85.

Çilek, S and A. Kaygisiz (2008). Breeding Value Estimation of Dairy Cattle Using Test Day Milk Yields for Brown Swiss Cows Reared at Ulaş State Farm. *J Anim Vet Adv*, 7(6): 703-706.

Dalal, D. S., S. S. Rathi and K. L. Raheja (1999). Genetic Evaluation of Hariana Sires for Test Day Milk Records and First Lactation Milk Yield. Indian J Anim Sci, 69(12): 1042-1043.

Ertuğrul, O., M. N. Orman and G. Güneren (2002). Some genetic parameters of milk production in the Holstein breed. *Turk J Vet Anim Sci*, 26(3): 463-469.

Ferreira, W. J, N. M. Teixeira., R. F. Euclydes., R. D Verneque., P. S Lopes., R. D. Torres., A. A. Wenceslau., MVGB. da Silva and M.N. Magalhaes (2003). Genetic Evaluation of Holstein Cattle Using Test Day Milk Yield. *R Bras Zootec,* 32(2): 295-303.

ICAR – International Committee for Animal Recording (2011): Guidelines Approved By The General Assembly Held İn Riga, Latvia On June 2010. (http://www.icar.org/ Documents/ Rules% 20and% 20regulations/ Guidelines/Guidelines_2011.pdf).

Kaya, I., Y. Akbas and C. Uzmay (2003). Estimation of Breeding Values for Dairy Cattle Using Test-Day Milk Yields. *Turk J Vet Anim Sci*, 27(2): 459-464.

Khan, M. S, G. Bilal., I. R. Bajwa., Z. Rehman and S. Ahmad (2008). Estimation of Breeding Values of Sahiwal Cattle Using Test Day Milk Yields. *Pakistan Vet J*, 28(3): 131-135.

Ledic, I. L., R. D. Verneque., L. El Faro., H. Tonhati., M. L. Martinez., M. D. Oliveira., C. N. Costa., R. L. Teodoro and L. D. Fernandes (2002). Genetic Evaluation of Gir Breed Sires for Milk Production at the Control Day and 305-ds of Lactation. *Revista Brasileira De Zootecnia Brazilian J. of Animal Science*, 31(5): 1964-1972.

Meyer, K. (1997). DFREML 3.0α Program Package and User Notes. Animal Genetics and Breeding Unit, Univ. New England, Armidale, New South Wales, Australia.

Nigm, A. A., S. A. Attallah., S. Abou-Bakr and R. R. Sadek (2003) A Study on Applying Test Day Model for Genetic Evaluation of Milk Yield of Holstein Cattle in Egypt. *Egypt J Anim Prod*, 40, 89-98.

Orhan H, E. Efe and M. Şahin (2004). SAS Yazılımı ile Istatistiksel Analizler. 1. Baskı, 234s, Tuğra Ofset, Isparta, 2004.

Pool, M. H and T. H. Meuwissen (1999). Prediction of Daily Milk Yields from a Limited Number of Test Days Using Test Day Models. *J Dairy Sci*, 82(7): 1555–1564.

Powell, R. L and H. D. Norman (2006). Major Advances in Genetic Evaluation Techniques. J Dairy Sci, 89(4): 1337-1348.

Ptak, E. and L. R. Schaeffer (1993). Use of Test-Day Yields for Genetic Evaluation of Dairy Sires and Cows. *Livest Prod Sci*, 34(1): 23-34.

Rehman, M. S. and M. S. Khan (2009). Genetic Diversity of Hariana and Hissar Cattle from Pakistan using Microsatellite Analysis. Pakistan Vet. J., 29: 67-71

Reents, R., L. Dopp., M. Schmutz and F. Reinhardt (1997). Experiences with a Genetic Evaluation Using Test Day Data. *Interbull Bull*., 16: 48–52.

Saatcı, M., Z. Ulutaş., I. O Devi and İ. Akkuş (2000). Environmental Effects Variance Components and Estimated Breeding Value in Dalaman State Farm. *Atatürk Üniv Ziraat Fak Derg*, 31(2): 97-101.

Schaeffer L. R., J. Jamrozik., G. J. Kistemaker and J. V. Doormal (2000). Experience With a Test Day Model. *J Dairy Sci,* 88(3): 1135-1144.

Seyedsharifi, R., M. P. E. Nasab and A. Sobhani (2008). Estimation of Genetic Parameters and Breeding Values for Test-Day and 305-Days Milk Yields in Some Iranian Holstein Herd. *J Anim Vet Adv*, 7(11):1422-1425.

Shadparvar, A. A and M. S. Yazdanshenas (2005). Genetic Parameters of Milk Yield and Milk Fat Percentage Test-Day Records of Iranian Holstein Cows. *Asian Aust J Anim Sci*, 18(9): 1231-1236.

Swalve H. H (1995). The Effect of Test Day Models on the Estimation of Genetic Parameters and Breeding Values for Dairy Yield Traits. *J Dairy Sci*, 78(4): 929-938.

Tailor, S. P and B. Singh (2011). Genetic evaluation of sires using test day yield. Indian J. Anim. Sci. 81 (8): 882–885.

Ulutaş Z., N. Akman and Ö. Akbulut (2004). Estimates of genetic and environmental (Co) variances for 305-day milk yield and valving intervals in Holstein Fresian cattle. *Turk J Vet Anim Sci*, 28(1): 101-105.

Ünalan, A and Z. Cebeci (2004). Estimation of genetic parameters and correlations for the first three lactation milk yields in Holstein Friesian cattle by the REML method. *Turk J Vet Anim Sci*, 28(6): 1043-1049.

Wiggans, G. R and M. E Goddard (1997). A Computationally Feasible Test-Day Model for Genetic Evaluation of Yield Traits in the United States. *J Dairy Sci*, 80(8): 1795-1800.

Yilmaz, I., E. Eyduran, A. Kaygisiz, and K. Javed, (2011). Estimates of genetic parameters for lactation shape parameters with multivariate statistical technique in Brown Swiss Cattle. Int. J. Agric. Biol., 13: 174–178.