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Original Contribution

AN INVESTIGATION ON THE LACTATION BIOMETRY OF BLACK AND WHITE DAIRY CATTLE HERDS RAISED IN SOME PUBLIC INTENSIVE FARMS IN TURKEY

M. I. Soysal[1*], F.G. Sirlar[2], E.K. Gurcan[3]

[1]Trakya University. Agriculture Faculty of Tekirdag, Department of Animal Science
[2] Trakya University Institute of Natural Applied Sciences Tekirdag, Turkiye
[3]Trakya University, Agriculture Faculty of Tekirdag, Department of Animal Science, Turkiye

ABSTRACT

The lactation curve characteristics of Black and White cattle raised in Tahirova (Balıkesir) and Kumkale (Çanakkale) State farms in Turkey were investigated.

The first lactation records of 64 Black and White cows date back to the period ranging from 1994 through 1995 and these cows comprised 35 heads from Tahirova and 29 heads from Kumkale. The aim of the study was to estimate the milk yield using the lactation curve. Lactation curve characteristics of each group were classified according to the cause of variation.

The parameters of lactation curves, such as persistency of lactation(s) , peak yield (Ymax) and peak yield days (Tmax), beginning milk yield (A), coefficient of rising before peak yield (B), and rate of declining after peak yield (C), were calculated according to three mathematical models. The Wood Model, the Goodall Model and the Grossmen Model were used to estimate the parameters of lactation curve. The models were compared on the basis of goodness of fit. The expected lactation curves for each of the models were determined. The differences between the expected and observed curves were used as test criteria for choosing best fitted models. The relationship between day of lactation and test day lactation yields was also examined. The differences between expected test day yield and observed test day yield were observed.

The data were grouped according to the number of lactation. The original data were converted to the value required for the working formulae from every individual data used for obtaining the parameters of models used in the equation of several lactation curve models for Wood, Goodall and Grosman models as shown below in the respective order.

$Y= a.n^b e^{-cn}$, $Y= an^b e^{(-cn+dD)}$, $Y=an^b e^{-cn[1+usinx+vcosx]}$

Goodall model took into account seasonal effect. The expected test day milk yields were calculated for every individual according to the used equations. Then average predicted test day milk yield were compared with expected test day milk yield average in order to show the degree of fitness in every sub group by square of correlation coefficient (R^2).

Keywords: Biometry of lactation, lactation curve, wood, Goodall, Grossman models

INTRODUCTION

The term lactation describes milk secretion from the mammary gland starting from parturition to drying off in the mammalian species such as cattle The amount of milk per day varies during the lactation period. Milk production in dairy cattle has a special pattern in which daily milk yield increases firstly thereafter declines gradually. The measure of variation in the daily milk yield is obtained by means of mathematical equations. The shape and type of lactation curve can be described by several models. Most of the functions describing lactation curves contains the components of the coefficient of beginning yield (a), coefficient of rising (b) , coefficient of decreasing (c), coefficient of persistency (S), average maximum daily peak yield (Ymax) and the time after parturition when the peak yield occurs (Tmax).

The independent and dependent variables of lactation curves given above are as the time for times (n) or (t) lactation yields in (n) th day of lactation respectively. The coefficients which may be derived directly

* Correspondence to: Prof. Dr. M.I. Soysal, Trakya University. Agriculture Faculty of Tekirdag, Department of Animal Sci., 59030 Tekirdag, Turkiye; E-mail: misoysal@ttnet.net.tr

from the model equations of lactation curves are the maximum daily yields, the time to attain maximum (peak) milk yield, and the persistency of lactation which expresses the rate of decline.

The graphs of daily milk yield against the time (days of lactation) is called lactation curve. Besides, all the components of other persistency itself have important factors influencing the efficiency of the production, with their economic importance.

Wood (1967) classified the lactation curves into two types; these are flat lactation curves (relatively homogenous fluctuations) which are more advantageous than those of steep lactation curves (non-homogenous fluctuations).

The mathematical explanation of lactation curve is known as biometry of lactation. Wood (1967) examined the daily milk yield variations, as the daily yield as the function of time and the proposed non-linear mathematical equations were as shown below:

$y=a.t^{b} e^{-ct}$

The logarithmic transformation of this model is as follows:

$\ln (y)= \ln (a)+b\ln(t) -c(t)$

This function is called Gamma function or Wood model. In this model persistency is obtained using the following formula.

$S=-(1+b)\ln c$

Several different methods are available for obtaining the value for persistency.

Schneeberges (1978) divided the methods for determining the shape of lactation curves by means of persistency of lactation into three main groups as follows:

First method for measuring persistency of lactation consists of ratio calculations. Sanders (1923) called this ratio shape figure. Second method group of measuring the persistency of lactation curve utilizes the milk yield's variation in three parts of lactation period as early (time to peak), middle (from peak to the noticeable decline in milk yield due to pregnancy) and late part of lactation.

Osterkorn (1974) claimed early middle and late lactation curve followed the parabolic, linear and hyperbolic variations.

The third group of calculation methods of measuring persistency uses total lactation periods and utilizes the linear regression and inverse polynomial regression.

Second non-linear model of lactation curve is called the Grosman Model.

Grosman et al. (1986) modified the Wood (1967) model by taking into account the effect of calving season. The differences between Grosman model and the Wood model were the coefficient of the day of year of the yield obtained as measured radian (u) and the coefficient of calving season (v).

Grossman model is as shown below:

$Y= a.t^{b}.e^{-ct.} (1+u.\sin(x)+v\cos (x))$

The persistency values of Grosman models were obtained using following formulas:

$S= - (1+b)\ln (C)$ or $S=c^{[-b+1]}$

The major aims of investigation lactation curve were as prediction whole and partial lactation yield, and obtaining selection criteria with high heritability.

Goodal (1986) has also developed non-linear function describing the lactation curves as shown below:

$Y=a.t^{b}.e^{[-ct+dD]}$

The linear transformation of this model was as shown:

$\ln (y)=\ln (a)+n\ln(t)-ct+dD$

Grosman et al. (1986) developed new equations modifying the Woods original models called Modified Gamma Function. This model is as shown below:

$Y=an^{b}e^{-ct}[1+u\sin(x)+v\cos(x)]$

The linear transformation of this model is,

$\ln (Y)= \ln(a)+b \ln(t)-ct+u\sin(x)+v\cos(x)$

Where (x) represents the day of year of the daily yield measured in radians. This model takes into account the influence of season to the lactation curve [for October – March: D=0 and for April-October: D=1]; (d) represents the coefficient of season.

Several authors studied the parameters of lactation curves of cattle breeds of Brown Swiss, Holstein crosses, Jersey, Yellow Pied White Cattle and Native Black Cattle, respectively, raised in Turkey (Akbulut, 1990; Şekerden,1991; Kaygısız,1999).

Papaljcsik and Bodero (1988) compared the efficiency of 20 different mathematical models describing lactation curve using the magnitude of mean square of error (differences between predicted and observed milk yield). They concluded that Wood model had the lowest mean square of error.

Several studies were also conducted to clear the genetic properties of lactation curves parameters.

Soysal and Gürcan (2000), had also studied several lactation biometrical characteristics of Black and White cattle raised in Turkey. They had shown that the data obtained from their studies fitted into the Grossman model.

Akbulut (1998) reviewed the studies conducted for obtaining heritability, genetic and phenotypic correlations of persistency.

According to this review heritability ranged from (0,14) to (0,50) showing the possibilities of being as good selection criteria.

This study also showed that the phenotypic correlation between lactation milk yield and persistency was relatively low and mostly positive as against the relatively high and positive genetic correlation between the same traits. The heritability of the (c) coefficient was higher than other coefficients.

Panda, (1983) used exponential, parabolic, inverse polynomial and gamma function to investigate the lactation curve of exotic breeds.

Akbulut et al. (1998) also showed in their review that the heritability of the coefficient of a ,b,c and (s) were low in general and ranged from 0,05 to 0,35.

MATERIAL AND METHODS

The study material consisted of first lactation records of Black and White Cattle raised in the Public Intensive Dairy Cattle Operations in Balıkesir and Çanakkale provinces of Turkey in the period of 1994-1995. Milk yields were recorded twice per month and during the lactation period. Three non linear equations were used in this study (Wood, 1967, and Godall, 1986; Grossman, 1986). The meanings of the coefficients in the formula have been explained earlier. The original data were converted to the value required for the working formulae from every individual data used in obtaining the parameters of models used.

The persistency values were calculated by using the formula given below,

$S=[[-(1+b)][\ln c]]$ or $S=c^{(-b+1)}$

The time required to reach peak yield (T_{max}) was estimated as the ratio (b/c). The peak yield (Y_{max}) was estimated using the following formula,

$Ymax=a(b/c)^b e^{-b}$

The correlation coefficient (r) between the observed milk yield and predicted milk yield according to the equations used for test day yield data were also calculated. The square of correlation coefficients (R^2) was used to compare the models. The accuracy of estimation according to models was determined by also calculating the Mean Square Deviation (MSD).

The data were analyzed using Statistica Program of Quasi-Newton method (Statsoft inc,1994).

Table 1: The parameters of lactation curve according to several non-linear levels in the population investigated.

Population	Balıkesir Population (Tahirova)			Çanakkale Population (Kumkale)		
Models	Wood Model	Goodall Model	Grossman Model	Wood Model	Goodall Model	Grossman Model
	$X_{ort} \pm S_x$	$X_{ort} \pm S_x$	$X_{ort} \pm S_x$	$X_{ort} \pm S_x$	$X_{ort} \pm S_x$	$X_{ort} \pm S_x$
A	18.77 ± 1.95	11.02 ± 2.19	22.92 ± 6.56	15.50 ± 1.46	8.24 ± 1.64	17.32 ± 1.73
B	0.156 ± 0.04	0.140 ± 0.03	0.22 ± 0.05	0.108 ± 0.04	0.161 ± 0.03	0.10 ± 0.003
C	0.006 ± 0.002	0.003 ± 0.0004	0.004 ± 0.0007	0.004 ± 0.001	0.002 ± 0.0003	0.001 ± 0.0001
D		1.64 ± 0.28			1.66 ± 0.32	
R	0.84 ± 0.02	0.85 ± 0.02	0.90 ± 0.01	0.75 ± 0.03	0.75 ± 0.03	0.84 ± 0.002
R^2	0.75 ± 0.02	0.75 ± 0.02	0.82 ± 0.02	0.63 ± 0.03	0.63 ± 0.34	0.72 ± 0.003
V			0.012 ± 0.42			0.01 ± 0.02
U			-0.011 ± 0.04			-0.06 ± 0.3
Equation	Wood Model $Y=at^b e^{(-ct)}$		Goodall Model $Y=at^b e^{(-ct+dD)}$		Grossman Model $Y=at^b e^{(-ct)}[1+usinx+vcosx]$	

RESULTS AND DISCUSSION

The parameters of lactation curve estimated in the material are on **Table 1**.

The characteristics of lactation, such as persistency (S), maximum peak yield (Y_{max}) and length of peak yield (T_{max}) are given on **Table 2**.

Table 1 shows that all curves had the typical lactation curve characteristics with all positive coefficients.

The differences between populations were not significant. In Balıkesir population highest (R^2) were obtained from Grossman (0.82 ± 0.02) and Çanakkale populations; lowest (R^2) were obtained from Wood and Goodall model (0.63 ± 0.03).

In Balıkesir and Çanakkale populations Grossman model was the best fitted model with coefficient of determination of (0.82 ± 0.02) and (0.72 ± 0.003) respectively.

Table 2: The persistency, peak yield and the time after parturition following peak yield of lactation curve according to the several models investigated

Population	Balıkesir Population			Çanakkale Population		
Models	Wood	Goodall	Grossman	Wood	Goodall	Grossman
Persistens (S)	6.19	6.85	6.74	6.53	7.15	7.59
Peak Yield (Y_{max}) kg	26.42	16.24	44.46	19.67	13.73	24.84
Peak Yield Length (T_{max}) day	24.42	42.60	55	24.56	64.40	100

As is shown from **Table 2** the maximum and minimum coefficients of persistency were 6.85 for Goodall Model and 6.19 for Wood Model in Balıkesir population respectively. Maximum and minimum persistency values were found as 7.59 for Grossman and 6.53 for Wood model in Çanakkale population. The maximum and minimum peak yield values (Ymax) were found as 44.46 for Grossman model and 16.24 for Goodall model in Balıkesir population. The highest and lowest (Ymax) values were obtained as 24.84 for Grossman model and 13.73 for Goodall model in Çanakkale population.

The time after parturition when the peak yield occurred (Tmax) was found at maximum in Balıkesir population with a value of 55 for Grossman model whereas the minimum length of peak yield was obtained as 24.42 in Wood model in the same population. Maximum and minimum peak yield days were 100 for Grossman model and 24.56 for Wood model in Çanakkale population.

Lactation curve of populations investigated according to the several models and the observed and predicted daily milk yield according to the several models is also given on **Table 3**.

Table 3: The observed and predicted daily milk yield (kg) according to the several models

Population	Balıkesir (Tahirova) Population				Çanakkale (Kumkale) population			
Days of lactation	Observed daily milk yield (kg)	Predicted daily milk yield			Observed daily milk yield (kg)	Predicted daily milk yield		
		Wood	Goodall	Grossman		Wood	Goodall	Grossman
30	22	26.32	16.11	43.24	20.46	19.63	13.23	23.10
60	23.6	24.16	16.09	44.34	20.73	18.55	13.73	23.19
90	22.1	21.19	15.44	42.70	20.83	16.99	13.60	23.33
120	21	18.25	14.65	40.14	19.60	15.36	13.21	23.38
150	19.63	15.56	13.62	37.92	19.83	13.80	12.71	23.66
180	17.80	13.18	12.66	34.76	20.13	12.34	12.15	24.08
210	16.75	11.12	11.72	31.84	18.90	11.00	11.56	24.49
240	15.97	9.34	10.82	29.30	17.60	9.78	10.96	24.69
270	15.25	7.84	9.96	26.88	16.40	8.68	10.36	24.55
300	12.96	6.56	9.16	24.57	14.73	7.70	9.78	24
R^2		0.75	0.75	0.87		0.63	0.63	0.72

It is concluded that Grossman model suited best in the lactation curve studied. The results were in accordance with Soysal, M.İ. (2000).

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