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EFFECT OF DIFFERENT FACTORS ON LACTATION CURVE IN BUFFALO COWS

P. PENCHEV[1]*, M. BOICHEV[2], Y. ILIEVA[1], TZ. PEEVA[1]

[1]Agricultural Institute - Shumen, Bulgaria
[2]"Konstantin Preslavski" University of Shumen, Bulgaria

ABSTRACT

Four hundred and nine first-lactation Bulgarian Murrah buffalo cows, having calved on the farm of Agricultural Institute - Shumen within the period 1964-2005, were assigned with the aim to study the effects of different factors on lactation curve. Using the software products LSMLMW and MIXMDL, eleven LS-analyses were carried out, the sources of variance included in the models being: the fixed effects of age at first calving, pregnancy-related status, lactation month, days in milk, calendar month of calving, and period of calving. The results indicate that lactation month exerts substantial specific effect on the variance of average test-day milk (F= 310.35; P<0,001), defining the lactation curve as statistically significant. The effect of the factor days in milk determines steadiest lactation curve in the buffaloes with longest lactation period and, at the same time, relatively little differences in average test-day records. The effect of age at first calving is only expressed in significantly higher peak yield in the case of latest calving, test-day records being not affected. The environmental factors, calendar month of calving and period, have unsubstantial effect on lactation curve.

Key words: buffaloes; LS-analysis; lactation curve

INTRODUCTION

Lactation performance in dairy animals concerns not only quantity traits subjected to recording but also an essential aspect related to the pattern of productive ability of the body throughout the lactation curve. In many authors' considerations the ideal lactation profile is a curve with high peak and a moderate decrease afterwards (Sölkner and Fuchs, 1987; Dekkers *et al*., 1998; Grossman *et al*., 1999).

Peak yield, being the moment that determines the lactation curve to the greatest extent, varies among species, as well as among buffalo breeds like Nili-Ravi (Zakarriyya, 1995; Chaudhary *et al*., 2000), Indian Murrah (Dahama and Malik, 1991), Surti (Birader, 1990), and Egyptian buffalo (Mansour *et al*., 1992). In the Bulgarian Murrah and crossbreeds the peak productivity is in the second month post calving (Polihronov *et al*., 1977; Peeva *et al*., 1988).

Lactation curve is to be considered chiefly a physiologically determined trait, as it depends on the number of mammary epithelial cells and their secretory activity, and accounts for the increase of milk yield to peak lactation and for the decline after that (Capuco *et al*., 2003). It is to certain extent genetically determined both in the bovine (Macciotta *et al*., 2006a) and the bubaline (h^2= 0.15-0.33, Elmaghraby, 2009) species, which is important from selection viewpoint. Ludwick *et al.* (1943) suggested that a major portion of the variation in lactation persistency is a result of the inheritance of factors or genes which govern the development and the rate of function of various endocrine glands, the influence of the sire or dam being detectable in this aspect.

In the conditions of different countries the lactation curve of buffalo cows has been reported to be to chief extent affected by the environmental factors related to

***Correspondence:** E-mail: pen.penchev@gmail.com
Agricultural Institute - Shumen,
3 Simeon Veliki Blvd.,
9700 Shumen, Bulgaria

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management, climate and fodder resources (Chaudhary *et al*., 2000; Amin, 2003; Macciotta *et al*., 2006b; Anwar *et al*., 2009). According to some studies, there is also significant effect of lactation duration (Metry *et al*., 1994; Gajbhiye and Tripathi, 1999; Chaudhary *et al*, 2000; Elmaghraby, 2009) and age (Tekerli *et al*., 2001; Catillo *et al*., 2002; Macciotta *et al*., 2006b).

In 1988, Peeva and co-workers studied the persistency index in the national buffalo population and established significant effect of farm (herd). Viewing in perspective the bulk of thorough research works on a variety of buffalo breeds on global scale, the effects of a greater spectrum of factors on lactation curve in the Bulgarian Murrah breed have not been investigated.

The present study was initiated to test the specific effect of different factors on lactation curve in the Bulgarian Murrah buffalo cows.

MATERIAL AND METHODS

The study assigned 3929 monthly test-day records of 409 first-lactation Bulgarian Murrah buffalo cows, having calved on the farm of Agricultural Institute - Shumen within the period 1964-2005.

The data were processed using the softwares LSMLMW and MIXMDL (Harvey, 1990), the all-records model (MDL_{ALL}) expressed by the following equation:

$$Y_{i,q} = \mu + AFC_i + PS_j + LM_k + DIM_g + CM_l + P_q + e_{i,q},$$

where, $Y_{i,q}$ is the test-day milk yield of an individual with *i*-th age of first calving, *j*-th pregnancy related status, *k*-th lactation month, *g*-th days in milk, and *l*-th month of calving, and *q*-th period of calving;

μ - the average value of the trait test-day milk yield;
AFC_i - the fixed effect of age at first calving (*i*= 1...4);
PS_j - the fixed effect of pregnancy-related status (*j*= 1...3);
LM_k - the fixed effect of lactation month (*k*= 1...10);
DIM_g - the fixed effect of days in milk (*g*= 1...3);
CM_l - the fixed effect of calendar month of calving (*l*= 1...12);
P_q - the fixed effect of period of calving (q= *1*...7);
$e_{i,q}$ - the residual error.

A regressor was included in the 305-day milk yield in two classes.

Ten other LS-analyses for each separate lactation month were also carried out, the relevant models involving the same sources of variance with the following modifications: for first month (MDL_{FIRST}) the factors lactation month (LM_k) and pregnancy-related status (PS_j) were excluded; for second to tenth month ($MDL_{SECOND+}$) only lactation month (LM_k) was excluded.

RESULTS

The analysis of variance of the all-records model (Table 1) was fitted at relatively satisfactory proportion of the variation explained by the model (R^2= 0.681). It is apparent that the factor lactation month, determining the lactation curve, has a pronounced, highly significant effect expressed by the value of F= 310.35 (P<0.001).

The results indicate that days in milk and pregnancy related status play significant effect on daily milk yield, although with low degree of significance (P<0.05). The effect of period of calving is also significant (P<0.01). The other environmental factor, season of calving, and age at first calving do not affect daily records significantly (P>0.05).

Table 1: Analysis of variance by MDL_{ALL} (R^2= 0.681, CV= 22.4)

Sources of variance	df	MS	F
Factors			
Age at first calving	3	2.153	1.30 n.s.
Pregnancy related status	2	5.823	3.51 *
Lactation month	9	514.881	310.35***
Days in milk	2	5.766	3.48 *
Calendar month of calving	11	2.304	1.39 n.s.
Period of calving	6	5.398	3.25 **
Regressor			
Productivity level	1	4714.623	2841.81***

Degrees of significance: *** – P<0.001; ** – P<0.01; * – P<0.05; n.s. – P>0.05

Table 2 shows that the first-lactation buffaloes attain the peak of their productivity at month two post partum - 7.299 kg. The change in milk yield from second to fourth month is relatively little (7.8%), while after this stage productivity undergoes progressive decline by 16% to month five and 24% to month six, so to drop down to 46% of the peak yield at month ten.

The results in Table 2 indicate that the differences among the classes of the factor lactation period are within the range of 0.179 kg only.

Except for the first month, the ANOVAs for the separate lactation months (Table 3) were fitted at relatively reliable coefficients of determination (R^2= 0.535 to R^2= 0.707). Of all factors most prominent is the

Table 2: Test-day milk yield as affected by lactation month and days in milk (MDL_{ALL}), kg

Classes of the factors	n	LSM ± SE
Lactation month		
First	409	6.961 ± 0.082
Second	409	7.299 ± 0.081
Third	409	7.133 ± 0.079
Fourth	409	6.728 ± 0.078
Fifth	409	6.118 ± 0.076
Sixth	409	5.548 ± 0.075
Seventh	409	4.842 ± 0.074
Eighth	395	4.346 ± 0.072
Ninth	367	3.793 ± 0.073
Tenth	304	3.360 ± 0.079
Days in milk		
210–290 d	766	5.721 ± 0.061
291–370 d	1603	5.575 ± 0.048
Over 370 d	1560	5.542 ± 0.057
Overall LS-mean	3929	5.612 ± 0.043

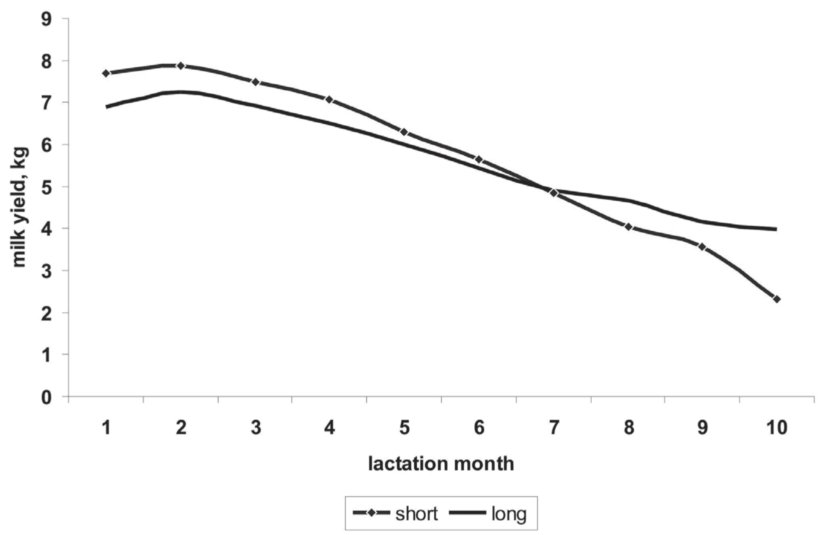

Fig. 1: Lactation curves in the cases of short and long days in milk (intermediate days in milk not shown)

Table 3: F-values from the analyses of variance by MDL_{FIRST} and $MDL_{SECOND+}$

Lactation month	R^2	CV	*Factors* Age at first calving	Pregnancy related status	Days in milk	Calendar month of calving	Period of calving	*Regressor* Productivity level
df			3	2	2	11	6	1
First	0.333	28.5	2.40 n.s.	-	3.33 *	2.59 **	2.00 n.s.	114.38 ***
Second	0.598	17.7	3.83 *	0.66 n.s.	4.79 **	1.08 n.s.	1.05 n.s.	402.06 ***
Third	0.679	16.2	2.24 n.s.	0.28 n.s.	4.39 *	2.67 **	6.00 ***	517.97 ***
Fourth	0.707	15.4	0.62 n.s.	0.00 n.s.	5.21 **	1.09 n.s.	3.29 **	622.69 ***
Fifth	0.666	17.9	0.56 n.s.	0.91 n.s.	1.27 n.s.	1.74 n.s.	1.55 n.s.	469.95 ***
Sixth	0.617	19.6	2.11 n.s.	0.01 n.s.	1.75 n.s.	1.56 n.s.	1.76 n.s.	348.84 ***
Seventh	0.644	21.2	1.45 n.s.	0.45 n.s.	0.96 n.s.	2.03 *	0.46 n.s.	399.95 ***
Eighth	0.603	26.2	3.19 *	1.47 n.s.	4.60 *	1.35 n.s.	1.63 n.s.	324.28 ***
Ninth	0.569	26.9	2.03 n.s.	1.95 n.s.	5.42 **	2.46 **	0.52 n.s.	278.45 ***
Tenth	0.535	29.1	1.73 n.s.	0.05 n.s.	17.43 ***	1.44 n.s.	0.49 n.s.	170.95 ***

Degrees of significance: *** - P<0.001; ** - P<0.01; * - P<0.05; n.s. - P>0.05

Table 4: Monthly milk yield as affected by days in milk (MDL_{FIRST} and $MDL_{SECOND+}$), kg

Lactation month	Classes of the factor						Overall LS-mean	
		210–290 d		291–370 d		over 370 d		
	n	LSM ± SE	n	LSM ± SE	n	LSM ± SE	n	LSM ± SE
First	90	7.691 ± 0.254	162	7.135 ± 0.181	157	6.886 ± 0.200	409	7.237 ± 0.139
Second	90	7.885 ± 0.209	162	7.514 ± 0.198	157	7.242 ± 0.216	409	7.547 ± 0.178
Third	90	7.474 ± 0.153	162	7.036 ± 0.127	157	6.931 ± 0.148	409	7.147 ± 0.105
Fourth	90	7.076 ± 0.133	162	6.728 ± 0.103	157	6.509 ± 0.123	409	6.771 ± 0.081
Fifth	90	6.292 ± 0.140	162	6.106 ± 0.101	157	5.994 ± 0.124	409	6.130 ± 0.079
Sixth	90	5.629 ± 0.387	162	5.693 ± 0.387	157	5.432 ± 0.396	409	5.585 ± 0.378
Seventh	90	4.833 ± 0.145	162	5.018 ± 0.124	157	4.898 ± 0.146	409	4.916 ± 0.106
Eighth	78	4.029 ± 0.155	162	4.419 ± 0.111	155	4.654 ± 0.137	395	4.367 ± 0.088
Ninth	50	3.553 ± 0.167	162	3.841 ± 0.098	155	4.158 ± 0.114	367	3.851 ± 0.082
Tenth	8	2.314 ± 0.390	145	3.244 ± 0.104	151	3.967 ± 0.119	304	3.175 ± 0.145

effect of days in milk, significantly affecting milk yield in the first four months and from eighth to tenth month of lactation, the F-value at the peak month being F= 4.79 (P<0.01). Figure 1 shows that in the case of short lactation (up to 290 d) the milk yield records for the first four months are higher, by 0.643 kg at month two, while for the conclusive three lactation months it is lower (detailed data in Table 4). Hence the constructive general impression that the buffaloes with longer lactation periods have more gradually declining curve, i.e. more evenly distributed productivity throughout. The lactation curve of the buffaloes with medium days in milk (291-370 d) is positioned intermediately.

Table 3 indicates the effect of age at first calving on test-day milk records, which is mostly insignificant. Yet significant, albeit at low statistical degree, is established to be its effect on the peak month productivity, month two (F= 3.83, P<0.05). The highest peak yield belongs to the buffaloes with highest calving age - by 0.719 kg higher as compared with the earliest calvers (Figure 2). It is noteworthy that in the late calvers the first half of the lactation curve is relatively dynamic, in comparison with the gradual curves for the lower classes of the factor (as they resemble each other, only the lowest class represented in Figure 2). In the case with the latest age at calving the relative decline from second to third month is twice faster - 6.9%, as compared with the change of 2.9% in the earliest class. From month three to four the drop is even better pronounced (16.0% versus 5.6%) while after that point the differences in monthly milk yield between the late and early calvers are negligible rendering the further dynamics of the lactation curves practically identical until the end of the lactation period.

The other factors are generally unsubstantial sources of variance. Average daily milk yield (Table 1) is affected significantly by period of calving (P<0.01) and pregnancy-related status (P<0.05). As for the records for the different lactation months (Table 3), noticeable is only the effect of the environmental factors, especially of period, on the milk yield of the post-peak months.

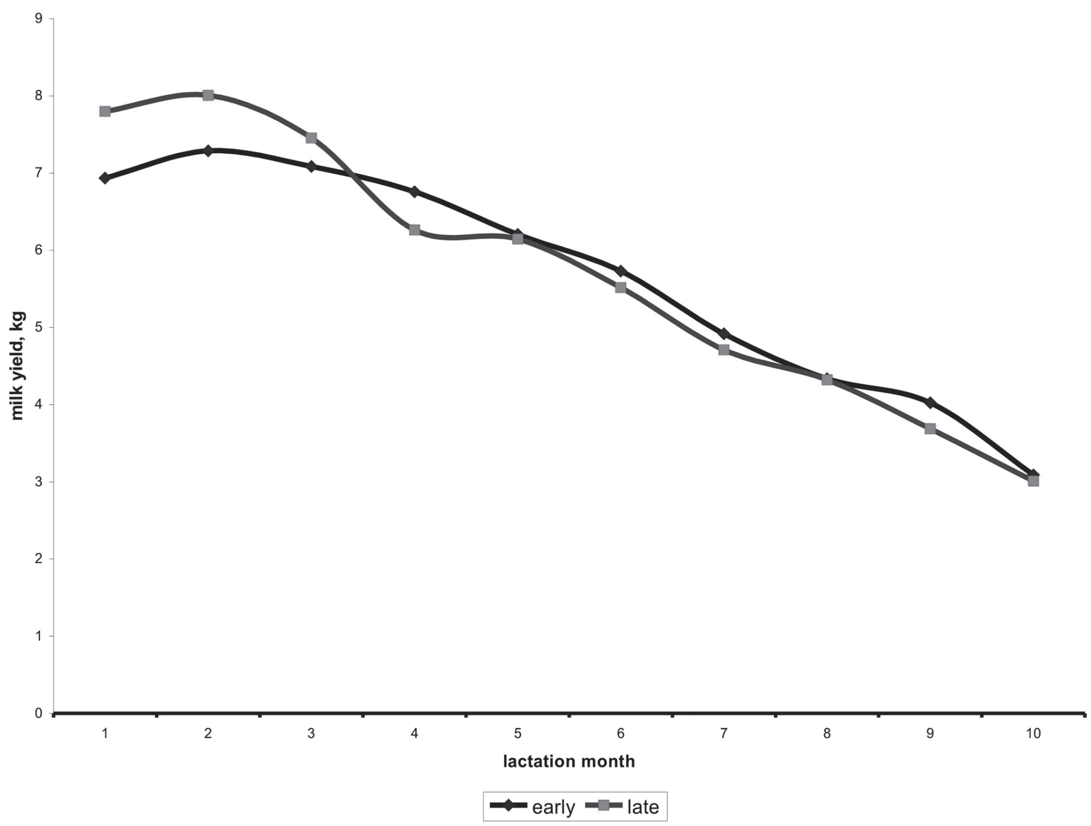

Fig. 2: Lactation curves in the cases of early and late calving (the two intermediate classes of age at first calving not shown)

DISCUSSION

The ANOVA results (Table 1) primarily indicate that the factor lactation month, representing the dynamics of milk production throughout lactation, has a pronounced highly significant effect, which is important for the interpretation of other results. In the present study first lactation curve does not differ substantially from those in other reports on different breeds in Bulgaria and abroad (Polihronov *et al*., 1977; Chaudhary *et al.*, 2000; Catillo *et al*., 2002). However, in comparison with other studies (Tekerli *at al*., 2001; Elmaghraby, 2009) Bulgarian Murrah buffaloes appear to have relatively low dynamics, implying more gradual and steady performance throughout lactation. Unlike ours, those studies have treated lactations at different parities, but, as Ludwick *et al*. (1943) pointed out, dairy animals have the capacity to maintain the specific shape of their lactation curves through all their productive life, which applies to the buffalo as well (Zakariyya *et al.*, 1995; Tekerli *et al*., 2001).

The substantial effect of lactation month implies that significant changes in productivity take place during lactation which is considered chiefly physiologically dependent, according to the common stance (Catillo *et al*., 2002; Capuco *et al*., 2003; Leclerc *et al*., 2008). Besides the diminished activity, apoptosis rate and renewal capacity of the secretory cells (Capuco *et al*., 2003), post-peak decline in productivity is due to the preparation of the metabolism for the hazardous transition period (around parturition) and especially for the period of adipose mobilization during early next lactation (Knight, 2001), and most commonly to pregnancy (Qureshi *et al*., 2007; Penchev *et al*, 2009). All this necessitates adequate udder cares and physiology-based feeding to maintain high levels of galactopoiesis as long as possible.

In this aspect, significant effect of days in milk on lactation curve was established herein (Table 3 and Figure 1), commensurate with the majority of studies showing that the longer the lactation the more persistent its characteristics (Metry *et al*., 1994; Gajbhiye and Tripathi, 1999; Chaudhary *et al*, 2000; Elmaghraby, 2009). On the other hand, however, despite the significant effect on average test-day records (Table 1), the differences among classes of the factors are within the range of only two-hundred grams (Table 2).

Concerning the effect of age on lactation dynamics after parities of different orders, Catillo *et al*. (2002) established an increase in peak yield with increasing age and decline of curves that further gradually approach each other, explaining the significant effect of age on lactation milk yield in general. According to Dijkstra *et al.* (1997), this is due to underdeveloped udder and hence lower alveoli activity at younger age which is overcome with the advance in age as a result of increasing cell proliferation. In comparison with these observations, in our study solely on primiparous buffaloes there is no great variation in test-day records explained by the factor age at calving (Table 1). On the other hand, the LS-analyses indicate more abruptly changing lactation curve after a higher peak in the case of late first calving (Figure 2), though significance is established for the effect of the factor on the milk yield at peak month only (Table 3).

Such highly dynamic lactation pattern could disturb energy balance, reproductive efficiency and resistance to diseases (Swalve, 2000; Jakobsen *et al*., 2002) associated with higher produce costs (Sölkner and Fuchs, 1987; Dekkers *et al*., 1998). As applied to the present case, this suggests that conception at earlier (optimal) age of buffalo heifers is expected to result in better-balanced metabolic status throughout lactation, without affecting lactation productivity. Besides, it is expected to have favourable effect on profitability in buffalo herds (Peeva, 2000; S. Khan *et al*., 2008), in contrast to the recommended delayed conception for economical and other reasons in bovine heifers (Ptak *et al.*, 1993; Leclerc *et al*., 2008).

The factor period of calving has an apparent effect on average daily milk but none on peak month. Though, its significant effect on post-peak productivity can be noticed, rendering it the only non-physiology-related factor defining the differences in the decline up to month four. Period is commonly understood as a sheer environmental factor (Leclerc *et al*., 2008), but herein we can consider it characterized with certain genetic aspects, in view of the fact that our study covers a long period of creation and development of the Bulgarian Murrah breed.

In the present case month of calving (resp., season) has significant effect neither on average milk yield records nor on peak yield. Insignificant effect of season or period on different characteristics of the lactation curve has also been observed in the Bulgarian Murrah and other breeds worldwide (Peeva *et al*., 1988; Dahama and Malik, 1991; Tekerli *et al*., 2001; Elmaghraby, 2009), while according to the majority of reports the two factors significantly affect lactation curve in general, and persistency and peak yield in particular (Kaygisiz, 1999; Chaudhary *et al*., 2000; Macciotta *et al*., 2006b; Anwar *et al*., 2009). The existence of such conflicting results once again indicates that these stress factors may be overcome through better feeding and management.

Judging by the increasing values of the coefficients of variation of test-day milk yield with every subsequent month in the second half of the lactation (Table 3), it can be assumed that there are differences in lactation curves among the buffaloes. This more specifically implies that there must be relatively high variation in lactation persistency, as observed in other studies (Peeva *et al*., 1988; Geetha *et al.*, 2006; Elmaghraby *et al*., 2009), which is essential from selection viewpoint.

CONCLUSIONS

In the Bulgarian Murrah buffaloes lactation month exerts substantial specific effect on the variance of average test-day milk (F= 310.35; P<0.001), defining the lactation curve as statistically significant.

The effect of the factor days in milk determines steadiest lactation curve in the buffaloes with longest lactation period and, at the same time, relatively little differences in average test-day records.

The effect of age at first calving is only expressed in significantly higher peak yield in the case of latest calving, test-day records being not affected.

The environmental factors, calendar month of calving and period, have unsubstantial effect on lactation curve.

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