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PATTERNS OF LACTATION CURVE IN BULGARIAN MURRAH BUFFALOES FROM TWO FARMS

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Abstract

To assess the different patterns of lactation curve and their parameters, were assigned buffaloes from intensive and pasture farming with respectively 466 and 335 normal lactations. The effects of peak month on overall persistency (PI1), post-peak persistency (PIP) and peak yield (PMY) were tested via LSMLMW and MIXMDL. The curves of lactations with first (LC1), second (LC2), third (LC3) and fourth-plus (LC4) peak month were shaped through conventional statistics. The results show mass deviation from the typical curve, the LC1 lactations being 60%, while LC2 are 1/4. Delaying the peak from 1st to 3rd month, PIP decreases from 88.2 to 86.4% (P< 0.05), but with highest value (90.4%) is LC4 (P< 0.01). Most productive are the lactations with typical pattern (LC2), while LC1 have lower milk yield, despite the higher peak yield, but because of the lower productivity and overall persistency (PI1) after it. It was demonstrated that for the economics of buffalo farming persistency by itself is not the only important parameter, but actually its combination with peak yield and the positioning of the peak.

Key words: *buffaloes, lactation curve, peak month, persistency.*

INTRODUCTION

Lactation curve of buffalo cows is to a great extent dependant on non-genetic factors related to management, climate and fodder resources, as it has been reported on global (Chaudhry et al., 2000; Amin, 2003; Macciotta et al., 2006; Anwar et al., 2009) and national (Penchev et al., 2011) scale. The ideal shape of lactation dynamics is a curve with a peak as high as possible and, more importantly, with a gradual decline afterwards (Pryce et al., 1997; Dekkers et al., 1996; Grossman et al., 1999). Though not as persistent as in bovine cows, it was demonstrated by Borghese et al. (2013) on global scale that in the water buffalo species its pattern is similar, the peak yield being normally between 40-th and 50-th day of lactation.
More importantly, such lactation shape was observed in the Bulgarian Murrah in particular - both in earlier grading stage of the population (Polihronov et al., 1977) and at a more recent status of the developed breed (Penchev et al., 2011). Nevertheless, in our previous study in association with days-in-milk (Penchev et al., in press) was established deviation from the principal pattern of lactation curve for the last decade. Hence, the purpose of the present study was to assess the different patterns of lactation curve and their parameters in Bulgarian Murrah buffaloes from two farms.

MATERIALS AND METHODS

The study assigned milk yield test-day data from the record books of two farms for the period from 2003 to 2018. On one of the farms (Fm1) the buffaloes are housed in a tie-stall barn with an exercise yard, while on the other (Fm2) they are also in a tie-stall barn in the night but on pasture all through the day. From Fm1 was used the information about 466 normal and 115 short (minimum 90 days) lactations, from Fm2 - 335 normal and 58 short.
Three important parameters of lactation were studied to describe the dynamics of milk release throughout it: lactation curve, persistency of lactation, and peak milk yield.
Lactation curve. Because of the unequal number of lactation days from parturition to first test day, the pattern of the lactation curve was established via conventional statistical procedure after transformation of the test-day milk into actual lactation months. For this purpose, test-day records were initially divided into ten-day periods and then rearranged so the first test day, in particular, to be transformed into one, two or three ten-day periods. In this way,

all lactations could be aligned by their first ten-day period, and then every three ten-day periods grouped back to obtain on monthly milk yield. On this transformed monthly basis daily milk yield was subjected to data processing.

Analysis of variance of milk yield were carried out under the following model (MDL-1):

$Y_{fk} = \mu + H_f + PA_g + MO_i + YR_j + SE_k + R[DIM] + e_{fk}$,

where: μ is the mean value of the trait;

H_f - the fixed effect of herd/farm (f = 1…2);

PA_g - the fixed effect of parity (g= 1…11);

MO_i - the fixed effect of lactation month order (i= 1…7);

YR_j - the fixed effect of period of year of calving (j = 1…4): 2003-2006, 2007-2010, 2011-2014, and 2015-2018;

SE_k - the fixed effect of season of calving (k= 1…4);

$R[DIM]$ – the regression of days-in-milk;

and e_{fk} - the residual effect.

For that purpose, were used the software products LSMLMW and MIXMDL (Harvey, 1990). The LSM-estimates by the levels of the factor lactation month were used for the shape of the overall lactation curve, while conventional statistical procedure (CSP) was used for the patterns of lactation curve in the cases of peak yield in the first (LC1), second (LC2), third (LC3), and fourth-plus (LC4) month postpartum.

Persistency of lactation. Two indices were computed also on monthly basis:

- Overall persistency (PI1) - from 1st to 7th month, as the average ratio between the milk yield of each month (from second on) and of the previous month.
- Post-peak persistency (PIP) - as the average decline after established peak month down to 7th month, which includes milk yield for 7 months (6 ratios) when the peak is in the first month (i.e., PIP= PI1), 6 months when second month is peak, 5 months when third month, and 4 months when the peak is in the fourth month and later.

Analyses of variance of PI1 and PIP were carried out under the following model (MDL-2):

$Y_{fq} = \mu + H_f + PA_g + YR_j + SE_k + DIM_l + DO_m + PM_q + e_{fq}$,

where: μ, H_f , PA_g, YR_j, and SE_k are same as in MDL-1, while DIM_l here is the fixed effect of days-in-milk (l = 1…4) with classes 210-260, 261-305, 306-365, and >365 days; DO_m is the fixed effect of days open (m = 1…5) with classes 0, 1-40, 41-80, 80-120, and >120 days; and PM_q is the fixed effect of peak month (q = 1…4) - 1st, 2nd, 3rd, and 4th-plus.

Daily milk yield in the peak month (PMY). The order of the peak month was established for each lactation (including short lactations) as the maximal monthly milk yield among all available lactation months; in case of two or more consecutive months with equally highest yield, for peak month was taken the earliest. PMY was also subjected to Model-2.

Two relevant traits were studied additionally. Lactation milk yield (LMY) was analyzed via MDL-3, involving the same sources of variance, except for DIM which was included as a regression. DIM was analyzed as a trait via MDL-4, excluding DIM as a source of variance.

For the ease of reading, the abbreviations used in this work are as follows (in alphabetical order): CSP - conventional statistical procedure; DIM - days in milk; LC1, LC2, LC3, and LC4 - lactation curve in the cases of peak yield in the first, second, third, and fourth-plus month respectively; LMY - lactation milk yield; MDL-1 to MDL-4 - linear models; PI1 - overall persistency; PIP - post-peak persistency; PMY - daily milk yield in the peak month.

RESULTS AND DISCUSSIONS

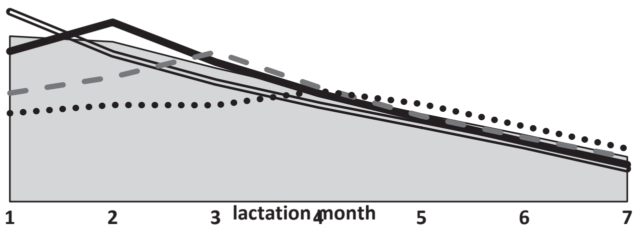
The results of the analyses of variance of the studied traits are presented in Table 1. Concerning daily milk yield per month, the data indicate that all sources of variance have highly significant effect. Most importantly, the factor with best expressed effect is lactation month (F= 511.3, P< 0.001). This significantly considerable effect and the td-values on Figure 1 render the established overall lactation curve highly reliable. The figure shows that practically the first two months are on the par for peak productivity, first month having 8.36 kg and second by only 2 percent lower - the difference being non-significant. The further differences, however, are all proved at P< 0.001. They show gradually increasing relative differences from 2nd-3rd month (10.4 percent) to 6th-7th (13.8 percent).

Table 1. F-values with levels of significance of P-value from the ANOVAs of monthly yield, persistency (PI1, PIP), peak yield (PMY), lactation yield (LMY) and DIM

Sources of variance	df	Milk yield MDL-1	PI1 MDL-2	PIP MDL-2	PMY MDL-2	LMY MDL-3	DIM MDL-4
Factors:							
Farm	1	20.4***	1.6 NS	13.8***	2.5 NS	13.6***	6.1 *
Parity	10	39.8***	3.2***	5.3***	11.3***	8.2***	5.0***
Period/Year	3	22.9***	5.4 **	7.9***	6.0***	5.7***	11.2***
Season	3	19.8***	4.8 **	18.1***	7.4***	3.6 *	0.9 NS
Lactation month	6	511.3***	-	-	-	-	-
Days-in-milk	3	-	3.4 *	30.2***	5.8***	-	-
Days open	4	-	0.6 NS	0.8 NS	2.6 NS	3.7 **	58.3***
Peak month	3	-	27.5***	7.3***	14.8***	3.7 *	1.9 NS
Regressions:							
Days-in-milk	1	222.6***	-	-	-	264.0***	-

Significance of P-value: *** - P≤ 0.001, ** - P≤ 0.01, * - P≤ 0.05, NS - P> 0.05

Figure 1 also represents the differences among the lactations with different order of the peak month. It is seen that these are four different patterns with dynamics that are similar only after fourth lactation month. The LC1 lactations have the highest peak yield but also fast decline to the second month of 15 percent. In this way, the LC1 lactations have by 1.3 kg higher milk yield in the first month while the overall superiority of the LC2 lactations after this is 2.5 kg. The great difference at the second month between LC1 (7.78 kg) and LC2 (8.81 kg) on the basis of the similar productivity at fifth month suggests significant difference in post-peak persistency to be expected. The relative difference from month to month in the case of LC1 (Figure 1) is averagely 11 percent while in the case of LC2 it is 13.5 percent. This is better demonstrated later on by the persistency indices in Table 2.



	1	2	3	4	5	6	7
Σ	8,36	8,18	7,33	6,56	5,84	5,16	4,45
LC1	9,15	7,78	6,87	6,13	5,48	4,81	4,06
LC2	7,87	8,81	7,51	6,51	5,71	4,94	4,20
LC3	6,51	7,04	7,84	6,70	5,77	5,08	4,44
LC4	5,86	6,13	6,12	6,59	6,17	5,44	4,71

Figure 1. Lactation curves (daily yield per lactation month): from overall data set (Σ) in LSM (MDL-1) and in dependence on peak month (CSP); td (MDL-1): 1-2 - P> 0.05, for all other differences P< 0.001

The overall lactation curve in this study deviates from the ideal pattern described earlier in cattle (Pryce et al., 1997; Dekkers et al., 1996; Grossman et al., 1999). It is principally different from the curves established in the breeds Nili-Ravi (Khan & Chaudhry, 2001), Murrah (Aspilcueta-Borquis et al., 2010; Singh M. et al, 2015*),* Mediterranean Italian (Catillo et al., 2002), and Anatolian breed (Şahin et al., 2015; Soysal et al., 2016) with peak yield in the second month. Furthermore, it is also different from the lactation curve observed in our previous studies on the Bulgarian Murrah - established peak in the fourth ten-day period (Polihronov et al., 1977) and in the second month in primiparous buffaloes (Penchev et al., 2011).

The distribution of patterns of lactation curves in dependence on their peak can be judged from the number of observations (n) in Table 2. It is seen that nearly 60% of the LC1 lactations, which is a deviation from the typical curve, while the LC2 lactations are less than one quarter. This observation is unprecedented in the literature on the water buffalo species, the percentage of atypical lactations being below 10%, as reported by Mansour et al. (1992), Khan & Gondal (1996) and Khan & Chaudhry (2001). As Table 1 shows, post-peak persistency (PIP) is strongly affected by all studied sources of variance (P< 0.001), except for days open (P> 0.05). The effect of peak month on PIP is expressed in F= 7.3 (P< 0.001), while on overall persistency it is even more determinative (F= 27.5, P< 0.001) at the expense of the non-significant farm/herd effect and the weaker influence of the environmental factors (P< 0.01) and of days-in-milk (P< 0.05).

As the results from Table 2 show, delaying the peak from first to third lactation month the post-peak persistency decreases from 88.2 to 86.4% (P <0.05), but the highest PIP = 90.4% belongs to the LC4 lactations (P <0.01). The LC4 lactations are with highest overall persistency, as well - by 13 percent relatively greater value as compared to LC1 – but with also significantly lowest milk yield. This lowest productivity is due to the low productivity of the initial 3 months, where the cumulative milk productivity is by 25% lower than the LC2 lactations, according to the data in Figure 1. The table shows that, judging by lactation milk yield, most profitable should be the LC2 lactations. The LC1 lactations have relatively low milk yield, despite the high peak yield, but because of the low persistency – post-peak persistency that should practically be viewed as overall persistency with significantly lowest index.

Table 2. Effect of peak month (LSM ± SE)

Curve type	n	PI1 MDL-2	PIP MDL-2	PMY, kg MDL-2	LMY, kg MDL-3	DIM, days MDL-4
μ	801	0.929 ± 0.009	0.880 ± 0.005	8.55 ± 0.16	1525.1 ± 25.7	285.4 ± 4.94
LC1	478	0.871 ± 0.009	0.882 ± 0.005	9.19 ± 0.19	1507.8 ± 27.1	274.7 ± 5.19
LC2	193	0.910 ± 0.011	0.870 ± 0.006	9.03 ± 0.20	1578.9 ± 29.2	284.0 ± 5.60
LC3	74	0.947 ± 0.015	0.864 ± 0.008	8.30 ± 0.28	1553.0 ± 40.8	275.7 ± 7.83
LC4	56	0.989 ± 0.016	0.904 ± 0.009	7.66 ± 0.29	1437.5 ± 42.0	288.7 ± 8.10
td		1-2**, 3-(2,4)* 1-(3,4)***, 2-4***	1-(2,3)*, 4-(2,3)**	1-3**, 2-3*, 4-(1,2)***	2-(1,4)*	NS

Significance of differences: *** - P< 0.001; ** - P< 0.01; * - P< 0.05; NS - non-significant

As most widely treated measure of persistency, the index of post-peak decline established in this study is higher compared to that reported for the Anatolian buffalo (Tekerli et al., 2001) and especially to the Egyptian buffalo (Elmaghraby, 2009), but lower than Nili-Ravi (Zakariyya et al., 1995) and the Mediterranean Italian (Catillo et al., 2002). It is lower also compared to our previous study (Penchev & Peeva, 2013), in view of the included data not only about 305-day lactations but also such with length of down to 210 days.
It is demonstrated herein that persistency (in the worldwide sense, post-peak persistency) by itself is not the only important parameter for the economics of dairy buffalo farming. Actually, its combination with peak yield and especially the positioning of the peak are more essential. In this context, the study also demonstrated the usefulness of the alternative measures of persistency, namely the role of overall persistency index, including the possible initial milk yield increase and a second-month peak that result in higher milk productivity throughout lactation. As they are associated with an economic loss, the dependencies and causes for the established skewed pattern of lactation dynamics are further to be studied.

CONCLUSIONS

The highly significant effect of lactation month (P<0.001) in this study proves the established overall lactation curve with first month peak productivity. The mass deviation from the typical curve (for the bubaline species and for the Bulgarian Murrah in particular) is expressed in a portion of nearly 60% of the lactations with first month peak, while those peaking in the second month are less than one quarter.

Peak month has highly significant effect on post-peak persistency ($P<0.001$). Delaying the peak from first to third month, PIP decreases from 88.2 to 86.4% ($P<0.05$). With highest PIP (90.4%) is the curve with the most delayed (fourth) peak month ($P<0.01$), but the lactation milk yield is lowest.

Judging by milk yield, most profitable should be considered the lactations with typical pattern (second month peak). The lactations with a peak in the first month have relatively low milk yield, despite the high peak-month yield, but because of their low persistency.

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