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Parameters of lactation shape as related to days-in-milk in buffaloes from two different farming systems

Параметри на лактационната крива в зависимост от продължителността на лактация при биволици от две различни системи на отглеждане

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ABSTRACT

Buffaloes from intensive (farm 1 - Fm1; 438 normal, 115 short lactations) and pasture (farm 2 - Fm2; 330 + 58 lactations) system were assigned to study lactation curve via ANOVA (LSMLMW and MIXMDL) per each 10-day period ("tenday"), as well as overall (PI1) and post-peak (PIP) persistency. Greatest is the effect of parity and season, also of year on 2nd-12th tenday. Persistency is affected by parity, year and season of calving, and especially by peak month and DIM (P≤0.001). The curves showed peak averagely at 2nd tenday in both herds. Compared to the buffaloes on pasture, Fm1 has significantly lower milk in initial two and in 15th to 21st tendays, defining slower decline to mid-lactation and faster after that. These differences in the curves predetermine a non-significant difference in PI1 between Fm1 and Fm2 (0.932 and 0.940) and a significant but still small superiority in PIP of Fm2 (0.893) over Fm1 (0.880). The lactations below 210 days are 17.8%, persistency being 0.859 to 0.742, and peak by 17 to 32% worse than normal lactation. Long and very long lactations' persistency is 0.923 and 0.950. Only very long lactations have a typical curve – 4th tenday peak, by 10% lower than normal lactation.

Keywords: buffaloes, days-in-milk, lactation curve, peak yield, persistency

РЕЗЮМЕ

Бяха включени биволици от интензивна (Fm1 – 438 нормални и 115 къси лактации) и пасищна (Fm2 - 330 + 58 лактации) технология на отглеждане, за проучване на лактационната крива чрез ANOVA (LSMLMW и MIXMDL) за всяка 10-дневка, както и на общото (PI1) и след-пиково (PIP) постоянство. Най-значим е ефектът на поредната лактация и сезона,, както и на годината за 2-ра–12-та десетдневка. Постоянството се влияе от поредната лактация, годината, сезона, и особено от пиковия месец и дойните дни (P≤0.001). Пикът е средно през 2-ра десетдневка в двете стада. В сравнение с биволиците на паша, Fm1 има достоверно по-ниска млечност в първите две и в 15та–21ва десетдневка, дефинирайки по-бавен спад до средата на лактацията и по-бърз след това. Тези разлики в кривите предопределят недостоверна разлика в PI1 между Fm1 и Fm2 (0.932 и 0.940) и и малко но достоверно превъзходство в PIP на Fm2 (0.893) спрямо Fm1 (0.880). Лактациите под 210 дни съставляват 17,8%, като постоянството е от 0,859 до 0,742, а пика е със 17 до 32% по-нисък от нормалната лактация. Постоянството на дългите и много дългите лактации е 0,923 и 0,950. Само много дългите лактации имат типична крива – пик в четвърто десетдневие, с 10% по-нисък от нормалната лактация.

Ключови думи: биволи, лактационна крива, пикова млечност, постоянство, продължителност на лактация

INTRODUCTION

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, accounting for the dynamics of milk yield, mostly the decline after the peak (Capuco et al., 2003). Ludwick et al. (1943) suggest that certain portion of the variation in lactation persistency is a result of the inheritance of factors or genes which govern the development and rate of function of various endocrine glands, the influence of both sire and dam being detectable. Other authors also view it as genetically determined to some extent (Macciotta et al., 2006a; Elmaghraby, 2009), which is important from selection viewpoint.

But still, lactation curve of buffalo cows is to a chief extent affected by 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., 2006b; Anwar et al., 2009) and national (Penchev et al., 2011) scale. Though some studies reported a significant effect of lactation duration on lactation curve parameters (Gajbhiye and Tripathi, 1999; Chaudhry et al., 2000) and even included lactations with less than 305 days in milk (Elmaghraby, 2009; Şahin et al., 2015), they have not regarded the differences between lactations with different length. Nor have it been done in the previous studies on the Bulgarian Murrah breed (Penchev et al., 2011; Penchev and Peeva, 2013), in view of the existing problem with short lactations in the national buffalo population.

The aim of the present study was to investigate the essential parameters of lactation dynamics in relation to days-in-milk in buffaloes bred in intensive and in pasture conditions: lactation curve in 10-day periods after rearrangement according to the date of calving, persistency in months of lactation based on the lactation curve, and peak month milk yield.

MATERIAL 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 farm farm 1 (Fm1) the buffaloes are bred intensively in a tie-stall barn with an exercise yard, while on farm 2 (Fm2) they are also in a tie-stall barn in the night but on pasture (within a National Reserve) all through the day from April to October. 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.

Because of the unequal number of lactation days from parturition to first test day, the pattern of the lactation curve was established on 10-day basis. So, each monthly test-day yield from the record book (except for the first) was divided by three into ten- day periods (Here, for the ease of the exposition, the term "tenday" was introduced), while the first test day, in particular, was transformed into one, two or three tendays. In this way, all lactations with minimum of 21 tendays (n= 801) could be rearranged to be aligned by their first tenday, and the whole lactation curve based on actual lactation tendays.

Analyses of variance of milk yield for each tenday from 1st to 21st (treated as separate traits) were carried out under the following model (Model-1):

$$Y_{fq} = \mu + H_f + PA_g + YR_j + SE_q + R[DIM] + e_{fq},$$

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); YR_j – the fixed effect of year of calving – in periods: 2003-2006, 2007-2010, 2011-2014, and 2015-2018 (j = 1...4); SEq – the fixed effect of season of calving (q = 1...4); $R[DIM]$ – the regression of days-in-milk; and e_{fq} – the residual effect.

For that purpose, the software products LSMLMW and MIXMDL (Harvey, 1990) were used.

The conventional statistical procedure (CSP) was applied to the same tendays (1st to 21st) of long (306-365 days) and very long (>365 days) lactations, separately.

Persistency of lactation was studied on monthly basis in 768 lactations (with minimum of 8 months in milk). For this purpose, were used actual lactation months, formed on the basis of aligned tendays. Two indices were computed:

- 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), for 6 months when second month is peak, for 5 months when third month, and for 4 months when the peak is in the fourth month and later.

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

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

where μ, H_f, PA_g, YR_j, SE_k and ef_q are same as in Model-1, while DIM_l here is the fixed effect of days-in-milk with classes 210-260, 261-305, 306-365, and >365 days (l = 1...4); and PM_q is the fixed effect of (the order of) peak month – 1st, 2nd, 3rd and 4th-plus (q = 1...4);

Model-2 was applied with the purpose to study the effects on the variance of PI1 and PIP and to obtain weighed LSM-estimate in normal lactations. Differences among persistency indices of lactations with different days-in-milk (including normal) were studied using CSP; short lactations being distributed in four classes: with at least 3 months in milk (i.e., including 2 monthly milk yield ratios in the formula), with 4 months (3 ratios), with 5 months (4 ratios), and with 6 months (5 ratios).

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 consecutive months with equally highest yield, for peak month was taken the earliest. Daily milk yield in the peak month (PMY) was also subjected to Model-2 for normal lactations, and to CSP for short, normal, and long lactations.

RESULTS AND DISCUSSION

The results of the 21 analyses of variance of tenday milk yield (Table 1) indicate that greatest is the effect of parity in all tendays. Environmental factors (season and year of calving) are significant sources of variance from 3rd tenday on, except for year from 13th to 17th tenday. The level of significance of all sources of variance is predominantly at $P \le 0.001$.

As the significance of F-values (Table 1) shows, farm/herd affects milk yield of 1st to 3rd and of 15th to 21st tenday (mostly at $P \le 0.001$), and, as Figure 1 shows, the resulted curves have their peak yield averagely at 2nd tenday in both herds, with small differences with 1st tenday. Compared to the buffaloes on pasture, those on Fm1 have significantly lower milk in the initial two months ($P \le 0.05$), the relative difference in peak yield being nearly 10 percent. This predetermines a slower average decline up to 12th tenday (relatively 2.53%), while after that it is faster (6.15%), based on the also significantly lower productivity from 15th to 21st tendays ($P \le 0.01$, $P \le 0.05$). The average decline in the lactations of the buffaloes from Fm2 is 3.40% up to 12th tenday and 4.15%, after that.

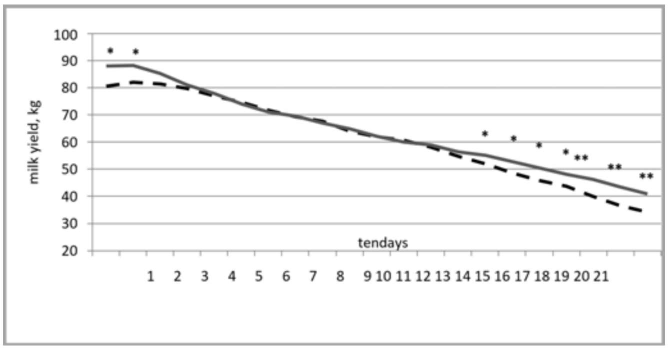

Figure 1. Lactation curves by tenday LSM-estimates from Fm1 and Fm2, with significance of P-values of t-test (Model-1)

Table 1. Levels of significance of P-values from the F-tests of ANOVAs – for 1st to 21st tenday milk yield and for persistency (PI1, PIP) and peak yield (PMY)

Sources of variance	df	Model-1	Model-2		
		Milk yield by tendays	PI1	PIP	PMY
Factors					
Farm	1	[1-2, 17-21]***, 16**, [3, 15]*, [4-14]NS	NS	*	NS
Parity	10	[1-15, 19-20]***, [16-18, 21]**	**	***	***
Year	3	[3-11]***, [2, 12, 20-21]**, [18-19]*, [1, 13-17]NS	*	***	**
Season	3	[5-16, 19-21]***, [17-18]**, [3-4]*, [1-2]NS	*	***	***
Peak mo	3	–	***	**	***
DIM	3	–	***	***	**
Regression					
DIM	1	[4-21]***, [3]**, [1-2]NS	–	–	–

PI1 – overall persistency index; PIP – post-peak persistency index; Levels of significance: ***P≤0.001, **P≤0.01,*P≤0.05, NS P>0.05

The regression of days-in-milk on milk yield (Table 1) is rather strong after 3rd tenday (P≤0.001), the F-value increasing from F=19.7 to F=175.2 (tabular data not presented) with the advance of lactation.

Figure 2 shows that, except for the first three tendays, the curve of the long lactations (306-365 days) resembles that of the average normal lactation curve. However, that of the very long lactations (>365 days) is different – a peak in the fourth tenday with milk yield in it by 10% lower than in average normal lactation, and relative rate of decline within only 3.9%, compared to 5.9% in 306-365-day lactations.

The normal lactation curve in this study is principally different from those established in the breeds Nili-Ravi (Khan and Chaudhry, 2001), Murrah (Aspilcueta-Borquis et al., 2010; Singh 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 previous studies on the Bulgarian Murrah, which applies to greater extent to the buffaloes raised on pasture. On the background of the established peak in the fourth tenday (Polihronov et al., 1977) and in the second month in primiparous buffaloes (Penchev et al., 2011), the detailed look at the curve of the buffaloes on Fm1 reveals that it is closer to the typical lactation curve as the peak is not so pronounced, the relative difference with 4th tenday coming to 2.5 percent only, while for Fm1 it is over 8 percent. All this also with the qualification that these studies were on 305-day lactations, in contrast to the 210-305 days in milk herein. Only the very long lactations demonstrate typical pattern of milk yield dynamics.

Table 1 also represents the results of the ANOVA's regarding persistency and peak yield of lactation of the studied buffaloes. Overall persistency (PI1) is affected by year (P≤0.05) and season of calving (P≤0.05) and especially by peak month (P≤0.001) and days-in-milk (P≤0.001).

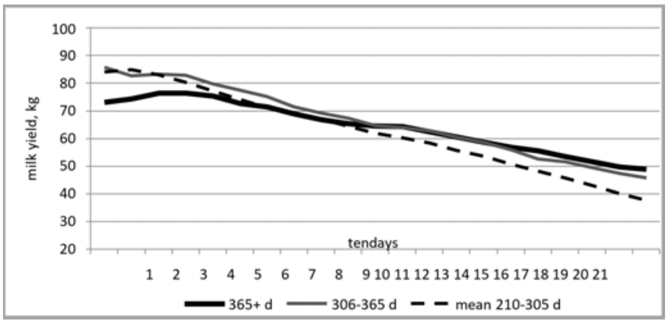

Figure 2. Curves by tendays of long and very long lactations (CSP) as compared to 210-305-day lactations (Model-1)

On post-peak persistency (PIP) the effects of parity (P≤0.001), year (P≤0.001) and season (P≤0.001) are stronger than the effect of peak month (P≤0.01).

The effect of herd on overall index of persistency is not significant (Table 1), the buffaloes from Fm1 having an average monthly drop of 6,8% (Table 2), and those from Fm2 – 6.0%. The difference regarding post-peak persistency is more pronounced and significant at P<0.05 – in favour of pasture system (PIP= 0.893), as compared to intensive system (PIP= 0.880). This significant difference (respectively the significant effect of farm/herd from Table 1) is consistent with the above established significantly slower decline in lactations' second half (Figure 1), which, on the other hand, combined with faster decline in the first post-peak months, determine the insignificant difference in PI1 between the two herds.

The mean LSM-estimates for the complete set of normal-lactation data show that overall and post-peak persistency are respectively 93.6 and 88.6% (Table 2), which, due to their weighed nature, are different from the CSP means – 89.6 and 86.6% (Table 3).

From the subsets of data of lactations with normal (n= 801) and short (n= 173) days-in-milk in Table 3, it is seen that the lactations with less than 210 days constitute 17.8% of the overall set of data. Overall persistency of normal lactation, being a focus of the study in view of the established peak milk yield in very early lactation, is PI1= 0.896. The most studied measure of persistency representing the post-peak decline is PIP= 0.866 – higher compared to that in 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 a previous study (Penchev and Peeva, 2013), in view of the included data not only about 305-day lactations but also such with length of down to 210 days.

To confirm the highly significant effect of days-in-milk on both PI1 and PIP from Table 1, Table 3 represents the CSP results about monthly persistency established in lactations of different length, the data about normal and long lactations corresponding to the curves in Figures 1 and 2. The two indices improve with the increase in days-in-milk (P<0.001), which is commensurate with the established correlation and effect of lactation length (Chaudhry et al., 2000; Penchev and Peeva, 2013). The relative differences in PI1 of normal with shorter lactations are within 17.2%, and with longer lactations – within 6%. It is also obvious from the table that the classes of lactations from 121 to 209 days have similar persistency. Noteworthy is the high variability of PI1 in the lactations with up to 6 months length, which implies existence of different causes (predetermined and accidental) for untimely dry-off that need further detailed investigation.

Days-in-milk is in direct proportion with the peak-month yield (Table 3) as well. Compared to 210-305-day lactations, the peak yield of very short lactations is by 32% lower and that of 181-209-day lactations – by 17%. As it was seen from Figure 2, the curve of the very long lactations (>365) is marked with most steady dynamics, closest to the ideal pattern of this dairy parameter (Pryce et al., 1997; Dekkers et al., 1996; Grossman et al., 1999).

Table 2. Effect of farm/herd on persistency (PI1, PIP) and peak yield (PMY) – LSM±SE (Model-2)

Classes of the factor	n	PI1	PIP	PMY, kg
Fm1	438	0.932 ± 0.006	0.880 ± 0.006	8.85 ± 0.200
Fm2	330	0.940 ± 0.006	0.893 ± 0.007	9.21 ± 0.207
td		n.s.	*	n.s.
μ	768	0.936 ± 0.006	0.886 ± 0.006	8.87 ± 0.173

PI1 – overall persistency index; PIP – post-peak persistency index

Table 3. Persistency indices (PI1, PIP) and milk yield in the peak month (PMY) of short (1.-4.), normal (5.) and long (6.-7.) lactations

Days in milk	n	PI1		PIP		PMY, kg	
		x ± SE	CV	x ± SE	CV	x ± SE	CV
1. 90-120	27	0.742 ± 0.035	24.6			5.91 ± 0.543	47.7
2. 121-150	35	0.851 ± 0.031	21.5			6.83 ± 0.487	42.2
3. 151-180	57	0.859 ± 0.038	33.7			7.52 ± 0.325	32.6
4. 181-209	54	0.857 ± 0.020	16.8			7.69 ± 0.344	32.9
5. 210-305	559	0.896 ± 0.006	14.7	0.866 ± 0.003	8.0	8.93 ± 0.086	22.6
6. 306-365	132	0.923 ± 0.005	5.7	0.898 ± 0.004	5.5	8.87 ± 0.200	25.9
7. >365	110	0.950 ± 0.006	6.2	0.923 ± 0.005	6.1	8.08 ± 0.181	23.6
t-test		1-(2,3,4,5,6,7)***, 2-(5,6,7)***, 3-(5,6,7)***, 4-(5,6,7)***, 5-(6,7)***, 6-7***		5-(6,7)***, 6-7***		5-(1,7)*	

PI1 – overall persistency index; PIP – post-peak persistency index

Here it is apparent that this highest persistency is associated with relatively low peak yield – by 10% lower than in normal lactation – which is decisive for the further lactation duration, hence for profitability as dependant on productivity.

CONCLUSIONS

There are specific differences in the lactation curves of the studied Bulgarian Murrah herds expressed in significantly higher peak in the buffaloes on pasture (Fm2), followed by faster decline until mid-lactation and more gradual second half, compared to intensively raised buffaloes (Fm1). This predetermines a non-significant difference in overall persistency of lactation (1^{st} to 7^{th} mo) and a significant but still small superiority in post-peak persistency of Fm2 (89.3%) versus Fm1 (88.0%) Only very long lactations appear to have a typical curve – with a peak after the third tenday; marked with high persistency and relatively low peak milk yield as well. The observed deviation from the typical lactation curve cannot be explained with the included comparatively short lactations (210+ days) since it was established in 306-365-day lactations as well. On the background of our previous studies, changes have taken place in the pattern of milk release from parturition to advanced lactation in the studied herds, which needs further investigation.

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