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VARIABILITY OF THE RATIO BETWEEN A.M. AND P.M. MILK YIELD IN BULGARIAN MURRAH BUFFALOES UNDER TWO DIFFERENT FARMING SYSTEMS

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Abstract

The study assigned 65 buffaloes under intensive farming (FM-I) with 922 test day records, and 73 buffaloes in pasture system (FM-P) with 2505 records. The analyses of variance (LSMLMW and MIXMDL), including also year, season, parity and test day, showed significant effect of milking time on milk yield (P<0.001) and of test day and its co-effect with milker`s group on p.m./a.m. ratio in the herds from FM-P (P<0.001) and FM-I (P<0.05), respectively. The random factor individual was also highly significant on FM-P. On FM-I p.m. yield was averagely by 18.1% lower than a.m., the differences between a.m. and p.m. maintained practically constant throughout lactation. Atypical, contrary pattern was found on FM-P - p.m. by 22.3% higher than a.m. yield, the difference becoming smaller until seventh month. The effect of lactation persistency on FM-P (P<0.05) is expressed in inverse proportion to the p.m./a.m. ratio. The substantial variability of a.m.-p.m. productivity, in particular its peculiarities in separate herds of buffaloes, should be taken into consideration in the development of prediction models.

Key words*: buffaloes, test day, a.m., p.m. milk yield.*

INTRODUCTION

Farming practices have shown that the best milking frequency for dairy buffaloes is twice daily. As Thomas (2004) summarizes, buffalo udder has comparatively small cisternal area and fraction which affords three-time milking, so that the milk yield can possibly increase by 10%, as shown in the studies of Dash et al. (1976) and Ludri (1985). Nevertheless, this is not economical due to unjustified management and labor related costs, which in some regions forces farmer to milk their buffaloes even once daily (Borghese et al., 2007).

It was suggested that the pattern of morning-evening productivity in dairy animals is due to the diurnal circadian rhythm governed by the hypothalamus and the endocrine system, for which a specific day-and-night regulatory gene is responsible (Plaut & Casey, 2012). Like dairy cows, in the bubaline species this pattern of diurnal milk release is usually expressed in higher productivity from the morning milking and lower from the afternoon. On this basis, models for prediction of test-day and lactation milk yield have been developed for the purposes of selection (Khan & Akram, 1997; Peeva et al., 2009b).

The literature on the a.m.-p.m. rhythmicity in the buffalo productivity is scarce, including the few reports abroad of Akram & Khan (1996), Khan & Akram (1997), Gonzaga & Lorenzo (2007), Sahin et al. (2015) and that of Peeva et al. (2009b) from our previous research on the Bulgarian Murrah. Giving the sooner only indirect idea on the issue, these studies suggest great variation of the p.m./a.m. ratio among herds - from 0.5 to nearly 1.

The present aim was to study the variability of the ratio between a.m. and p.m. milk yield to characterize the pattern of diurnal productivity in buffaloes from two different farming systems.

MATERIALS AND METHODS

The study assigned milk yield test-day data about morning (a.m.) and afternoon (p.m.) milking obtained from the record books of two farms for the period from 2011 to 2018. As per Table 1, from farm 1 (FM-I) was used the information about 65 buffalo cows with

110 lactations, and from farm 2 (FM-P) - respectively 73 buffaloes with 280 lactations. On FM-I the buffaloes are bred intensively in a tie-stall barn with an exercise yard, and on FM-P 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.

Table 1. Subsets of data per farm

Farm	Animals	Lactations	Test-day records	Records p.m.<a.m.
FM-I	65	110	922	799
FM-P	73	280	2505	691

The daily diet on FM-I from July to October involves 18 kg green foliage, 4 kg wheat straw, and 4 kg compound feed per capita, and from November the green roughage is replaced by 20 kg maize silage. On FM-P until October the buffaloes are fed 2 kg wheat straw, and 3.4 kg concentrate to supplement the pasture grazed, and from November - 3 kg alfalfa hay, 5 kg wheat straw, 4 kg compound feed, and 0.4 kg dried fodder beet chips.

The concentrate feed for both herds provides 1629 kcal energy and 96 g digestible protein and has the following composition: wheat - 15%, barley - 12%, corn - 56%, wheat bran - 10%, sunflower oilcake - 5%, dicalcium phosphate 0.6%, salt - 0.4%, and chalk - 1%.

On both farms the newborn calf is separated from the dam right after birth. The buffaloes are machine milked in cans twice daily - morning (a.m.) and evening (p.m.) - during which they are fed concentrate feed. In both herds the interval between milkings is 10 to 12 hours, depending on season. On FM-I milking is done in two groups, each of them served by a different milking operator, the two groups having been originally alloted on parity, productivity and temper basis. On FM-P the herd is served also by two operators milking the animals at random, not in personal groups.

The lactations that were used for data processing were chosen to have records at least to the seventh test day (only coupled a.m.-p.m. records) and for at least six test days. In this way, lactations with one missing test day record were also included, but in case of the sixth test day missing, the existence of seventh and eighth test day was required, and if the seventh was missing, the existence of eighth and ninth test day was necessary.

For the analysis of variance of milk yield per milking within each test day, datasets of 1844 records (double the test day records) for FM-I and 5010 for FM-P were processed. For that purpose, the software products LSMLMW and MIXMDL (Harvey, 1990) were used under the following overall model, herein referred to as MMY_{FM}:

$Y_{fq} = \mu + YR_g + SE_i + PA_j + TD_k + MT_q + e_{fq}$, where

- μ is the mean value of the trait;
- YR_g - the fixed effect of year of calving - in 2-year periods (g = 1…4);
- SE_i - the fixed effect of season of calving (i = 1…4);
- PA_j - the fixed effect of parity (j = 1…4);
- TD_k - the fixed effect of test day order (lactation month) (k = 1…6);
- MT_q - the time (a.m. or p.m.) of milking (q = 1…2); and
- e_{fq} - the residual effect.

For the analysis of variance of the ratio between milk yield from evening (p.m.) and morning (a.m.) milking for FM-I was used the following model, referred to as $AMPM_I$:

$Y_{fl} = \mu + YR_g + SE_i + PA_j + PER_l + PMY_m + MG*TD_o + e_{fq}$,

where μ, YR_g, SE_i, PA_j and e_{fl} are as above;

- PER_l - the fixed effect of lactation persistency level (l = 1…4);
- PMY_m - the fixed effect of peak milk yield (m = 1…4);
- $MG*TD_o$ - the co-effect of milker's group and test day order (o = 1…12).

For that purpose, persistency index was calculated as the average of the ratios second/first to sixth/fifth test day.

The model for FM-P ($AMPM_P$) was like $AMPM_I$, but including the factor test day (TD_k) instead of the co-effect ($MG*TD_o$) and also using the random effect of individual, represented by the animal ear tag number (NO_f, f = 1...73).

The conventional statistical procedure (CSP) was also applied to a.m., p.m. yield and the ratio between them.

RESULTS AND DISCUSSIONS

The analyses of variance of milk yield per milking that resulted from model MMY_{FM}

within the separate herds are presented in Table 2. Normally, the environmental factors were found to affect milk yield - year and season of calving respectively at P<0.001 and P<0.01. The physiologically determined effects parity and lactation month (test day) are even better expressed (P<0.001), especially the latter.

Table 2. ANOVAs of milk yield per milking (a.m. and p.m. coupled), including F-test and P-value - model MMY_{FM}

Sources of variance	df	FM-I		FM-P	
		F	P	F	P
Year	3	50.91	0.0000	11.08	0.0000
Season	3	5.33	0.0013	3.93	0.0083
Parity	3	31.48	0.0000	17.53	0.0000
Test day	5	89.88	0.0000	679.16	0.0000
Milking time	1	311.14	0.0000	198.40	0.0000

Noteworthy is the significance of the factor milking time as a source of variation of the trait milk yield per milking on FM-P (F= 198.4, P<0.001) and especially on FM-I (F= 311.1, P<0.001), implying differences between a.m. and p.m. productivity.

Table 3 demonstrates the difference between the farms regarding the pattern of a.m.-p.m. milk yield. The buffaloes on FM-I manifest significantly higher yield from the morning milking and lower from the afternoon (P<0.001), while the situation on FM-P is opposite – a.m. yield lower than p.m. (P<0.001). On FM-I, evening milk yield constitutes 44.0% of the total test-day milk yield (a.m. + p.m.), while on FM-P the percentage is 53.4%.

Table 3. Conventional statistics of a.m. and p.m. milk yield and of the ratio between them

Trait	FM-I (n = 922)		FM-P (n = 2505)	
	$\bar{x} \pm S\bar{x}$	CV	$\bar{x} \pm S\bar{x}$	CV
a.m., kg	3.805 ± 0.047	37.8	2.858 ± 0.025	43.5
p.m., kg	2.996 ± 0.040	40.3	3.267 ± 0.029	43.7
p.m./a.m.	0.819 ± 0.011	40.5	1.223 ± 0.009	38.0

All between-farm differences and all within-farm a.m.-p.m. differences significant at P<0.001.

The values of the ratio between a.m. and p.m. milk represent this dependance, indicating that in the FM-I buffaloes p.m. milk is by 18.1% lower than a.m., and on FM-P evening milk yield is by 22.3% higher than morning.

In fact, as Table 3 also shows, on FM-I this proportion is on the basiis of significanly higher a.m. milk yield - by nearly 1 kg compared to FM-P. Respectively, the mean test-day milk yield (a.m. + p.m.) is also higher, and the difference between a.m. and p.m. productivity is two-fold, compared to FM-P. Relatively expressed, this difference constitutes 11.9% of the total milk yield per test day on FM-I, and 6.7% on FM-P.

It is also notworthy that both a.m. and p.m. milk yield and the ratio between them have very high variation on both farms - from 37.8 to 43.7%. This calls for analysis of the variance of the ratio - an issue that has not been treated to date.

Table 4 contains the weighed values (expressed as overall LSM means) from the analysis of variance of the p.m./a.m. ratio. They are little higher compared to those resulted from the conventional statistical procedure - 0.823 and 1.262 for FM-I and FM-P respectively - but still in keeping with the observed dramatic difference between the two farms.

Table 4. ANOVAs of p.m./a.m. ratio within the farms FM-I (model $AMPM_I$) and FM-P (model $AMPM_P$), including F-test and P-value

Sources of variance	df	FM-I (LSM = 0.823)		FM-P (LSM = 1.262)	
		F	P	F	P
Individual		-	-	1.85	0.0000
Year	3	4.50	0.0040	6.46	0.0003
Season	3	0.41	0.7474	0.67	0.5758
Parity	3	1.46	0.2218	0.14	0.9337
Test day (TD)	5	-	-	5.72	0.0000
Milker x TD	11	2.02	0.0236	-	-
Persistency	4	0.50	0.7342	2.60	0.0499
Peak yield	3	2.27	0.0780	2.47	0.0504

In the first place, the table presents the effects on the ratio within the farms. In the FM-P buffaloes the variation of the ratio is to a greater extent explained by the factors included in model $AMPM_P$, compared to FM-I. The factors ear tag number and test day order are highly significant on FM-P (P<0.001), implying substantial differences among the individual buffaloes and defining the lactation curve. Similarly, on FM-I test day has a significant combined effect with milker's group ($P<0.05$).

In the buffaloes on pasture (FM-P), year of calving has pronounced effect, implying possible changes in management and nutritional conditions during the period of study, presumably variable condition of the available pasture. On FM-I, this effect is significant at $P<0.01$.

On the FM-I buffaloes the effects of persistency and peak yield are non-significant, while on FM-P they are marginal - respectively $P = 0.0499$ and $P = 0.0504$.

The results about the p.m./a.m. ratio in the intensively farmed buffaloes appear to be lower compared to the reported 93.4% by Peeva et al. (2009b) for the same herd, which is close the sooner to the finding for the Anatolian buffalo (Sahin et al., 2015). The ratio of FM-I is lower than the reported by Akram & Khan (1996) for the Nili-Ravi breed, and much higher than the value for Bulgarian Murrah buffaloes in the Philippines (Gonzaga & Lorenzo, 2007). More importantly, the buffaloes from FM-I are still in keeping with the commonly observed tendency for lower evening than morning productivity.

Nevertheless, the results about the farm on pasture are unprecedented - conrary to FM-I and to all other findings known to apply to the bubaline species. As Table 1 indicates, on FM-P the test-day records representing a typical pattern with p.m. milk yield lower than a.m. are only 27.6%, while on FM-I they are 86.7%. While the differences among the cited foreign studies might be due to different interval between morning and evening milking, this does not apply to the farms studied here.

The material of the study (Table 1) also shows that each FM-P buffalo participated with averagely 3.83 lactations. For comparison, on FM-I this number is 1.69 only, explaining to certain extent the relatively poorly fitted within-farm model. This is also implied in the higher total test-day milk yield of the intensively bred buffaloes, which is attributed to the problem with high incidence of short lactations on this farm and to the respective exclusions from that data subset.

On the basis of the significant effect of test day, Figures 1 and 2 represent the lactation curves from the a.m. and p.m. milking of the buffaloes from the two farms. In the first place, the figures demonstrate the difference between the farms, as per Table 3. The productivity of the FM-I buffaloes is presented by typical lactation curves (Figure 1), p.m. milk yield being lower than a.m. yield throughout lactation. The differences between morning and evening milk yield are practically uniform down to the seventh test day but, as related to the level of productivity, in fact the p.m./a.m. ratio declines.

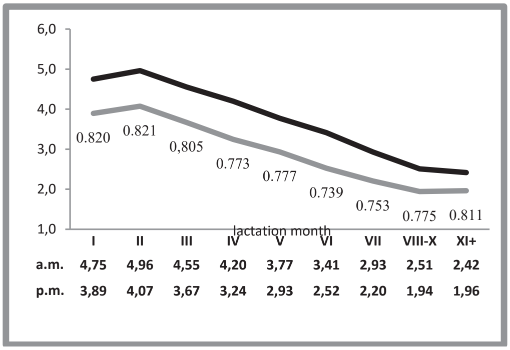

Figure 1. Lactation curves from a.m. (black) and p.m. (grey) milking on FM-I (by conventional statistical procedure), with the ratio bellow

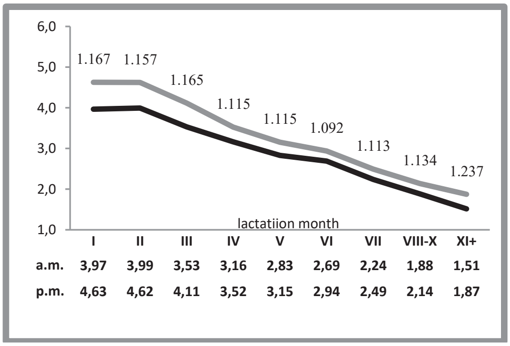

Figure 2. Lactation curves from a.m. (black) and p.m. (grey) milking on FM-P (by conventional statistics), with the ratio above

On FM-P the pattern is contrary – evening milk yield higher on all test days. The difference here, as Figure 2 graphically shows, is the faster decline in the p.m. compared to a.m. milk yield on this farm, rendering the difference between them diminishing to the seventh month. Nevertheless, despite this difference, there is also a decrease in the p.m./a.m. ratio, expressed mostly from fourth to sixth month. On both farms, in the last three months of the normal (305 days) lactation, the ratio increases as compared to the previous months. It is even higher at the end of the long lactations (over 10 test days), especially on FM-P where the ratio is highest, mostly due to the low level of productivity at this stage.

Except on test-day milk yield (or a.m. yield in particular), lactation prediction models are developed on the basis of lactation curve, empirically expressed by persistency index (Khan et al., 2005; Peeva et al., 2009a).

Figure 3 represents the effect of level of persistency. On FM-I it is non-significant (P> 0.05) and expressed in inconsistent trend, the p.m./a.m. ratio being highest in the lactations with lowest persistency. In the buffaloes on pasture, the highest ratio belongs to the lactations with lowest persistency and, in general, the ratio decreases with the increase of persistency, i.e. the closer the range of daily milk yield throughout lactation, the closer the range between morning and evening productivity.

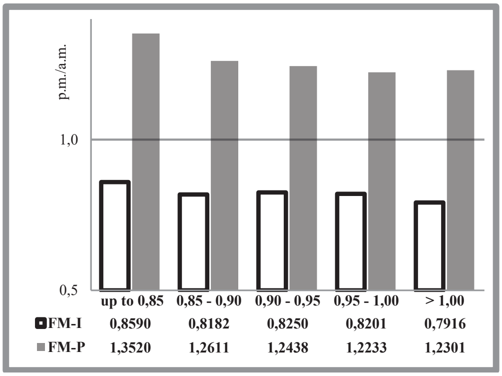

Figure 3. Effect of level of lactation persistency on FM-I ($P>0.05$, model $AMPM_I$) and FM-P ($P<0.05$, $AMPM_P$)

Presumably, since on FM-P the a.m. curve is more stable (persistent) than p.m., as seen in Figure 2, the persistency of total test-day milk yield is more dependent on the more unstable p.m. curve, i.e. the more persistent it is the smaller the difference with a.m. yield and the lower the p.m./a.m. ratio. In other words, the curve that is marked with lower productivity in this herd contributes more to the lactation persistency.

To summarize, the studied p.m./a.m. ratio showed to be highly variable within the studied farms, and to differ greatly among the previously established values in different herds worldwide (including FM-I and the cited sources), and especially between them and the atypical ratio in the FM-P buffaloes.

All this implies that the development of prediction test-day and lactation models in buffaloes should not blindly rely on partial records (usually a.m. milk yield) but take into consideration the possible peculiarities of the a.m.-p.m. ratio in separate herds.

CONCLUSIONS

The study established that in the FM-I buffaloes afternoon milk yield is averagely by 18.1% lower than morning, while on FM-P the pattern is atypical and contrary - p.m. by 22.3% higher than a.m. milk yield.

Test day is significant source of specific variance of the p.m/a.m. ratio in the FM-P buffaloes ($P<0.001$), and as a co-effect on FM-I ($P<0.05$). On FM-I the a.m.-p.m. difference stays practically constant throughout lactation, while on FM-P it becomes smaller down to seventh month, but in both cases the ratio declines.

The effect of persistency index on FM-P is significant ($P<0.05$) and expressed in highest p.m./a.m. ratio in the less persistent lactations, the ratio declining with the increase of the index. Year was found to be significant in both herds ($P<0.01$, $P<0.001$), while the other environmental factor season, peak yield and parity were not.

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