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Postpartum progesterone profiles in cows with different milk yields

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Abstract: *Postpartum progesterone profiles in cows with different milk yields.* The aim of the study was to determine progesterone profiles in postpartum dairy cows depending on their milk yield. Analysis was also made of the effect of milk production level and milk progesterone concentration on date of first estrus in cows. The study was performed with two herds of Polish Black-and-White Holstein-Friesian dairy cows. Twenty six cows in the Wielkopolska herd and 17 cows in the Małopolska herd were investigated. The full lactation milk yield of the cows from these herds averaged 9,921 and 7,640 kg, respectively. The cows were kept in a loose-housing system and received TMR diets. Milk progesterone concentration was measured with the FT Multilyser analyser. Milk samples were collected in the morning and evening on days 12, 19, 21, 28, 35, 40 and 42 postpartum. Data on milk yield and milk urea concentration from the first and second test-day milking were taken from RW-2 recording reports. The herd had a statistically significant effect on progesterone concentration in cow's milk, which for all the tested days averaged 15.5 mg/l in the Małopolska herd and 24.5 mg/l in the Wielkopolska herd. The level of the cow's daily milk yield had no significant effect on the milk progesterone concentration. Large individual variation was observed between the cows in milk progesterone concentration. The milk progesterone content was negatively correlated with the number of days from calving to first estrus. Daily milk yield had a significant effect on the date of first estrus after calving.

Key words: dairy cows, progesterone profiles, milk yield

INTRODUCTION

Estrus detection continues to pose many problems to dairy cow farmers. Despite advancement of knowledge and technological progress, the correct detection of estrus is in many cases difficult. These difficulties are due not only to poor work organization but also to the incidence of silent estrus (Zduńczyk et al. 2005, Kozdrowski et al. 2006). In addition, a high percentage of cows come into estrus at night (Kozdrowski et al. 2005). Estrus is easier to detect in herds of cows housed in free-stall barns, where various activity meters (most often pedometers) are used for estrus detection (Holman et al. 2011, Bruyčre et al. 2012, Chanvallon et al. 2014, Rutten et al. 2014). However, these meters cannot be used in tie-stall barns, which is the predominant type of barn in Poland (Banaszkiewicz 2017).

Considering various problems associated with estrus detection, research is ongoing to find new, automated, and more importantly, efficient methods of estrus detection (Bruyčre et al. 2012, Saint-Dizier et al. 2012, Homer et al. 2013). In comparative studies on efficiency of different estrus detection methods, the authors very often use milk progesterone concentration as the reference method (Morton et al. 2010, Holman et al. 2011, Bruyčre et al. 2012, Chanvallon et al. 2014). Today, the concentration of progesterone in cow's milk is increasingly measured with automated techniques (Saint-Dizier et al. 2012, Samsonova et al. 2014), including those used in field conditions (eProCheck® 2014).

Milk progesterone concentration is naturally dependent on the stage of estrous cycle, but cows exhibit differences in the level of progesterone (Friggens et al. 2008, Forde et al. 2012). The impact of the cow's milk production level and the associated energy balance on progesterone concentration in body fluids, including milk, is also relevant (Taylor et al. 2003).

The aim of the study was to determine progesterone profiles in postpartum dairy cows depending on their milk yield. Analysis was also made of the effect of milk production level and milk progesterone concentration on date of first estrus in postpartum cows.

MATERIAL AND METHODS

The study was performed with two herds of Polish Black-and-White Holstein-Friesian dairy cows. Twenty six cows in the Wielkopolska herd and 17 cows in the Małopolska herd were investigated. The full lactation milk yield of the cows from these herds averaged 9,921 and 7,640 kg, respectively. The cows were kept in a loose-housing system.

Progesterone concentration was measured in milk sampled in the morning and evening on days 12, 19, 21, 28, 35, 40 and 42 postpartum. Progesterone concentration was measured with the FT Multilyser analyser.

Data on milk yield (kg) and milk urea content from the first and second test-day milking were taken from RW-2 recording reports.

The day of first estrus after parturition was determined from automatic interpretation of changes in locomotor activity (pedometers), visual observations, and milk progesterone concentration.

The data were subjected to analysis of variance according to the following model:

$$Y_{ijkl} = \mu + G_i + M1_j + M2_k + \epsilon_{ijkl}$$

where:
μ – overall mean;
G_i – effect of i-th barn/herd (Wielkopolska farm, Małopolska farm);
$M1_j$ – effect of j-th daily milk yield during the first test-day milking (≤ 35 kg, > 35 kg);
$M2_k$ – effect of k-th daily milk yield during the second test-day milking (≤ 35 kg, < 35 kg);
ϵ_{ijkl} – random error.

Differences between the means were tested with the Scheffe test. In addition, coefficients of Pearson's correlation were calculated between values of the variables. Statistica 10 was used for the statistical calculations.

RESULTS AND DISCUSSION

There was a statistically significant ($P <$ < 0.05; $P < 0.01$) effect of herd on progesterone concentration in cow's milk (Table 1). In cows from the Wielkopolska herd, this hormone was almost twice as high on all test days as in cows from the

Małopolska herd. When considering the effect of herd, it should be noted that in both cases the cows were kept in a similar rearing system and were fed TMR diets, but differed in milk yield per lactation, which was higher by almost 2,300 kg in cows from the Wielkopolska herd. This factor may possibly explain the effect of herd on cow's milk progesterone concentration, although no statistically significant effect of daily milk yield on milk progesterone concentration was observed (Table 1).

Rabiee et al. (2002) found no effect of daily milk yield on plasma and milk progesterone concentrations. In turn, Stronge et al. (2005) showed a negative linear correlation between cow's daily milk yield and milk progesterone concentration. An inverse relationship was also reported by Reksen et al. (2002).

In our study, milk progesterone concentration showed wide variations, as evidenced by the high standard deviation in relation to the mean (Table 1). Also Friggens et al. (2008) called attention to the high individual variation between the cows for milk progesterone concentration.

Another parameter tested in our study was the number of days from calving to first estrus (Table 1). It averaged 32.8 days and was higher for cows from the Wielkopolska herd (34.8 days) compared to cows from the Małopolska herd (28.3 days). The daily milk yield, measured at the second test-day milking, had a highly significant effect on the number of days between calving and first estrus. In the higher yielding cows, first estrus after calving started later. No significant effect of the milk progesterone level on the date of first estrus after calving was observed.

Yet another parameter measured in our study was the cow's milk urea concentration (Table 1), which is an indicator of energy balance. Milk urea concentration was 214.4 mg/l in the milk from first test-day milking and 234.1 mg/l in the milk from second test-day milking. It was significantly (almost twice) higher in the milk of cows from the Wielkopolska herd, but fell within the normal range. In addition, daily milk yield had a statistically significant effect on the milk urea content, especially for milk from the second test-day milking (Table 1).

Table 2 shows the coefficients of correlation between the analysed parameters. As for the level of progesterone, relatively high and statistically significant coefficients of correlation were found between milk progesterone concentrations on different days after calving and the mean from these days. The highest coefficients were noted between milk progesterone concentration on days 21 and 28, and the mean (0.85 and 0.90, respectively). A negative correlation was found between the milk progesterone concentration and the number of days from calving to first estrus, in relation to both the individual days of the postpartum period and the mean progesterone concentration on these days.

The progesterone concentration was weakly correlated with the milk urea concentration – the coefficients of correlation can at best be described as average (Table 2). The progesterone concentration also showed a weak correlation with daily milk yield, which confirms the previous observation that daily milk yield of the cows had no statistically significant effect on the milk progesterone concentration.

TABLE 1. Effect of herd and daily milk yield on progesterone level, number of days to estrus, and urea level in cow blood

Item	Total	Herd		Daily milk yield			
				ML1		ML2	
		Małopolska	Wielkopolska	≤ 35 kg	> 35 kg	≤ 35 kg	> 35 kg
N	32	10	22	9	23	9	23
P12	20.4 ±11.0	15.3 ±5.5	22.8 ±12.1	17.4 ±7.6	21.6 ±12.0	20.1 ±11.1	20.6 ±11.1
P19	20.9 ±10.0	15.5^{a} ±5.9	23.4^{a} ±10.6	19.6 ±6.9	21.4 ±11.1	17.3 ±7.6	22.3 ±10.6
P21	20.2 ±9.8	14.0^{b} ±5.4	23.0^{b} ±10.2	16.7 ±5.9	21.5 ±10.8	19.7 ±10.0	20.3 ±9.9
P28	21.9 ±12.8	12.6^{A} ±4.6	26.1^{A} ±13.2	17.7 ±10.5	23.5 ±13.5	20.6 ±10.6	22.4 ±13.8
P35	23.0 ±10.7	17.3^{c} ±5.3	25.6^{c} ±11.6	23.2 ±11.3	23.0 ±10.7	25.1 ±9.1	22.2 ±11.4
P40	21.8 ±9.9	16.4^{d} ±5.8	24.2^{d} ±10.5	19.9 ±7.7	22.5 ±10.7	23.2 ±8.6	21.2 ±10.5
P42	23.5 ±10.8	17.3^{e} ±6.7	26.3^{e} ±11.2	20.2 ±10.0	24.7 ±11.0	26.4 ±14.2	22.3 ±9.2
P	21.7 ±8.0	15.5^{B} ±3.8	24.5^{B} ±7.9	19.2 ±7.3	22.6 ±8.3	21.8 ±8.1	21.6 ±8.2
R	32.8 ±11.6	28.3 ±9.3	34.8 ±12.2	30.0 ±11.5	33.8 ±11.8	23.6^{F} ±9.0	36.3^{F} ±10.7
M1	214.4 ±84.9	129.9^{C} ±64.0	252.8^{C} ±62.9	168.0 ±98.6	232.5 ±73.5	185.9 ±77.8	225.5 ±86.6
M2	234.1 ±84.8	126.9^{D} ±39.1	282.9^{D} ±44.8	177.4 ±83.6	256.3 ±76.0	187.7^{G} ±72.5	252.3^{G} ±83.7
M	224.2 ±79.6	128.4^{E} ±45.7	267.8^{E} ±45.7	172.7 ±84.3	244.4 ±69.5	186.8^{H} ±67.5	238.9^{H} ±80.4

P12, P19, P21, P28, P35, P40, P42 – milk progesterone content (ng/ml) on successive days after calving; P – mean milk progesterone concentration (ng/ml); R – number of days from calving to first estrus; M1 – milk urea concentration (mg/l) at first test-day milking; M2 – milk urea content (mg/l) at second test-day milking; M – mean milk urea concentration (mg/l); ML1 – daily milk yield (kg) at first test-day milking; ML2 – daily milk yield (kg) at second test-day milking; values designate the mean ± standard deviation; values marked with the same small letters differ at $P < 0.05$; values marked with the same small letters differ at $P < 0.01$.

TABLE 2. Correlations between progesterone level and number of milking days, and between urea level in blood and daily milk yield of the cows

Traits	P12	P19	P21	P28	P35	P40	P42	P	R	M1	M2	M	ML1	ML2
P12	1.00													
P19	0.41*	1.00												
P21	0.54**	0.75**	1.00											
P28	0.33	0.69**	0.79**	1.00										
P35	0.21	0.24	0.52**	0.69**	1.00									
P40	0.24	0.27	0.45*	0.60**	0.74**	1.00								
P42	0.24	0.30	0.42*	0.55**	0.43*	0.77**	1.00							
P	0.57**	0.70**	0.85**	0.90**	0.74**	0.77**	0.71**	1.00						
R	–0.24	–0.18	–0.20	–0.29	–0.28	–0.40*	–0.30	–0.36*	1.00					
M1	–0.02	0.15	0.27	0.41*	0.39*	0.38*	0.42*	0.39*	0.17	1.00				
M2	0.13	0.21	0.26	0.47**	0.42*	0.43*	0.38*	0.44*	0.24	0.76**	1.00			
M	0.06	0.19	0.28	0.47**	0.43*	0.43*	0.43*	0.44*	0.22	0.94**	0.94**	1.00		
ML1	0.06	0.02	0.10	0.13	0.04	0.08	0.01	0.09	0.27	0.40*	0.47**	0.46**	1.00	
ML2	0.09	0.05	–0.02	0.04	0.03	0.15	0.00	0.07	0.49**	0.25	0.58**	0.44*	0.58**	1.00

P12, P19, P21, P28, P35, P40, P42 – milk progesterone content (ng/ml) on successive days after calving; P – mean milk progesterone concentration (ng/ml); R – number of days from calving to first estrus; M – mean milk urea concentration (mg/l); M1 – milk urea concentration (mg/l) at first test-day milking; M2 – milk urea concentration (mg/l) at second test-day milking; ML1 – daily milk yield (kg) at first test-day milking; ML2 – daily milk yield (kg) at second test-day milking; * coefficients significant at $P < 0.05$; ** coefficients significant at $P < 0.01$.

CONCLUSION

In summary, it should be mentioned that the milk progesterone content did not depend on the daily milk yield of the cows. Because of the high individual variation between the cows for milk progesterone concentration, it would be appropriate to determine postpartum progesterone profiles for each cow, which could contribute to efficient estrus detection. The level of progesterone in cow's milk had no significant effect on the day of first estrus after calving.

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Streszczenie: *Profile progesteronowe w okresie poporodowym u krów o różnej wydajności mlecznej*. Celem pracy było określenie kształtowania się profili progesteronowych u krów mlecznych w okresie poporodowym w zależności od ich wydajności. Analizie poddano również wpływ poziomu wydajności mlecznej i zawartości progesteronu w mleku na termin wystąpienia pierwszej rui u krów. Badania przeprowadzono w dwóch stadach krów mlecznych rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej. Objęto nimi 26 krów w stadzie wielkopolskim i 17 krów w stadzie małopolskim. Średnia wydajność mleczna krów utrzymywanych w tych stadach wynosiła odpowiednio 9921 i 7640 kg mleka za laktację pełną. Krowy były utrzymywane w systemie wolnostanowiskowym i żywione z wykorzystaniem systemu TMR (ang. *total mixed ration*). Do oznaczenia zawartości progesteronu w mleku wykorzystano aparat FT Multilyser. Próbki mleka pobierano rano i wieczorem w 12. 19. 21. 28. 35. 40. i 42. dniu po wycieleniu. Z raportów wynikowych RW-2 odnotowano wydajność mleka oraz zawartość mocznika w mleku krów w pierwszym i drugim dniu próbnego udoju. Stwierdzono statystycznie istotny wpływ stada na poziom progesteronu w mleku krów, który wynosił średnio (ze wszystkich badanych dni) 15,5 mg/l w stadzie małopolskim i 24,5 mg/l w stadzie wielkopolskim. Nie stwierdzono statystycznie istotnego wpływu poziomu dziennej wydajności mlecznej krów na zawartość progesteronu w mleku. Wykazano duże zróżnicowanie osobnicze między krowami odnośnie zawartości progesteronu w mleku. Zawartość progesteronu w mleku była ujemnie skorelowana z liczbą dni od wycielenia do wystąpienia pierwszej rui. Stwierdzono istotny wpływ poziomu dziennej wydajności mlecznej na termin wystąpienia pierwszej rui po porodzie.

Słowa kluczowe: krowy mleczne, profile progesteronowe, wydajność mleczna

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