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DETERMINING THE RELATIONSHIP BETWEEN MILK UREA LEVEL AND SELECTED FERTILITY TRAITS IN HOLSTEIN-FRIESIAN COWS

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ABSTRACT

A total of 88,745 test-day milk yields (obtained up to 30 days before first insemination) from 55,685 Polish Holstein-Friesian cows were used to estimate the coefficients of simple correlation between milk urea level and selected indicators of fertility, age of cows, milk production level, herd size, season of first insemination, and lactation period. The increase in milk urea level had a significant ($P \leq 0.01$) effect on prolonging the calving interval (r = 0.03) and service period (r = 0.01), as well as on increasing the number of inseminations per conception (r = 0.02). The direction and magnitude of the relationships (expressed as the coefficient of correlation) between milk urea level and fertility varied within classes of cow's age, lactation period, season of first insemination, milk production level, and herd size.The present study showed that it would be beneficial to monitor dairy herds of Polish Holstein-Friesian cows for milk urea level which could contribute to improving their fertility.

Key words: dairy cows, Holstein-Friesian breed, milk urea level, correlations, fertility

INTRODUCTION

Production of urea takes place by conversion of ammonia, which is produced by rumen microbes during degradation of feed protein [Jaśkowski et al. 2006]. Urea is transported by blood to the kidneys and part of it diffuses to milk [Mucha and Strandberg 2011]. Research results show that taking into account nutritional considerations only, the optimum milk urea concentration for cows of large dairy breeds ranges from 150 to 300 mg·l^{-1} (2.5 to 5.0 mmol/l) [Skrzypek et al. 2005].

Monitoring the urea level in blood or milk may be useful for analysing the reasons for reproductive failure as well as the health status [Markiewicz 2003]. Measurement of milk urea concentration in herds provides an opportunity to formulate and plan a diet with proper protein content, which will optimize nitrogen utilization for milk production and avoid negative effects of high urea levels on herd fertility [Butler et al. 1996]. The negative effect of increased milk urea concentration on cow fertility was clearly shown by Rajala-Schultz et al. [2001], who emphasized that this precludes the introduction of quick prenatal care and prevention of possible pregnancy loss. Skrzypek et al. [2005] demonstrated that cow fertility is significantly related to the milk urea concentration. The best reproductive parameters were found in the cows in which the urea concentration of milk obtained from the milking preceding the first insemination had intermediate values (201–250 mg·l^{-1}), and in the animals characterized by low urea concentration of the milk (over 150 mg·l^{-1}) obtained after the insemination. Veerkamp et al. [2003] reported that the negative effect of low milk urea levels on cow fertility is due to insufficient intake of dietary protein, which results from the negative energy and protein balance during the early phase of lactation. This condition is increasingly frequent in high-yielding cows and lasts for the first 10–12 weeks of lactation.

The aim of the study was to determine the effect of selected factors on the relationship between milk urea levels and cow fertility.

MATERIAL AND METHODS

The SYMLEK database was used to gather information about milk urea levels in 88,745 test-day yields, obta-

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ined up to 30 days before the first insemination, in the first and second lactation up to day 180. The data were collected for 55,685 Polish Holstein-Friesian cows of Black-and-White variety, which were milk recorded in the Pomerania and Kujawy regions, first calved during 2005–2012, and were used until the end of 2014.

The CORR procedure [SAS 2014] was used to calculate the coefficients of simple correlation between test-day milk urea levels (up to 30 days before the first insemination) and indicators of cow fertility (calving interval, CI; service period, SP; services per conception, SPC), taking into account the effect of cow's age (primiparous and multiparous), production level in the herd from which the cow originated ($\leq$7000, 7001–9000 and >9000 kg milk), season of first insemination (spring: March to May; summer: June to August; autumn: September to November; winter: December to February), stage of lactation during the first insemination ($\leq$60, 61–90, 91–120, 121–150 and 151–180 days), daily yield ($\leq$20, 20.1–30, 30.1–40 and >40 kg milk), and number of cows in the herd ($\leq$20, 21–50, 51–200 and >200 cows).

RESULTS AND DISCUSSION

The cows were characterized by average fertility (CI – 426 days, SP – 54.8 days, SPC – 2.20) and the milk urea level averaged 210 mg·l^{-1} [Mordak 2008, Borkowska et al. 2012].

The coefficients of correlation obtained for the examined population between milk urea level and reproductive parameters were positive and significant, although they did not exceed 0.04 (Table 1). The increase in urea level was found to prolong SP and CI as well as increasing the dose of semen needed for conception (SPC). The findings of Sawa et al. [2011] confirm the negative effect of increased urea level on CI, SP and SPC, and the coefficients of correlation (0.050, 0.014 and 0.021) were similar to our results. Likewise in the studies cited by Mucha and Strandberg [2011], the increased milk urea level prolonged CI and reduced pregnancy rate, with no effect on SPC.

The analysis of the effect of cow's age, lactation period, daily production level, milk production level and herd size revealed that the direction and magnitude of the relationships between milk urea level and fertility showed variation.

The coefficients of correlation show that the relationships between milk urea level and cow fertility were stronger after the second calving compared to primiparous cows. The results of other authors [Sawa et al. 2011] also indicate that the length of CI is significantly correlated to the urea level, but unlike in our study, this correlation was stronger for primiparous cows (0.08) than for multiparous cows (0.04), for which the correlation coefficient was similar to that obtained in our study (0.04). The low coefficients of both phenotypic and genetic correlations between milk urea level and cow fertility were also reported by Hossein-Zadeh and Ardalan [2011]. The fertility parameter most strongly correlated to milk urea level was days open (DO), and the magnitude of correlation increased with the number of calvings. It was lowest for primiparous cows (r = 0.23) and highest in third lactation cows (r = 0.45), whereas in cows that calved twice, the coefficient of correlation was 0.35. For the other parameters under study (reproductive rest period, RRP; SPC; SP), the coefficients of correlation were low (close to zero).

The length of CI was significantly correlated to the milk urea level, and this correlation increased with increasing production level in the herd in which the cows were used. The correlation coefficients between milk urea level and length of CI increased from 0.03** in herds producing less than 7000 kg milk to 0.06** in herds yielding >9000 kg milk. In low- and medium-producing herds, the correlations for SP and SPC were not significant. Weak but significant correlations (r = 0.04**) occurred only in herds producing >9000 kg milk. According to Sawa et al. [2011], the coefficients of correlation between milk urea level and length of CI increased from 0.02** in herds producing less than 5000 kg milk to 0.08** in herds yielding more than 6000 kg milk, while the corresponding values for reproductive rest period increased from 0.04** to 0.11**.

The results for the effect of lactation period on the relationships between milk urea level and indicators of fertility show no significant correlations for length of CI as well as SP in cows that were first inseminated $\leq$60 days and between 121–150 days of lactation. For cows that were first inseminated during 61–90 and 91–120 days of lactation, the correlations between milk urea level and the parameters under discussion were significant and the coefficients assumed similar values (around 0.02**); increased correlation coefficients were observed, however, for the cows inseminated during 151-180 days of lactation (r = 0.03**). The relationships between milk urea level and SPC were significant within all classes of the lactation period and showed a tendency for their magnitude to increase with the time between first insemination and the preceding calving. According to Sawa et al. [2011], urea concentration in the fourth month of lactation would be the most useful for predicting cow fertility, although in this case, too, the coefficients of correlation did not exceed 0.06. Rzewuska and Strabel [2014] concluded that the magnitude of correlations between milk urea level and fertility traits during lactation is not constant. For the length of SP, CI as well as SPC, the correlation coefficient had negative values in early lactation, fluctuated around zero in mid-lactation (during the first inse-

Table 1. Coefficients of correlation between milk urea concentration and reproductive parameters

Tabela 1. Współczynniki korelacji między zawartością mocznika w mleku i wskaźnikami rozrodu

Factor Czynnik		n	CI, days OMW, dni	SP, days OU, dni	SPC II
	Total – Ogółem	88745	0.0316**	0.0066*	0.0184**
Lactation number Numer laktacji	1	55685	0.0280**	0.0011	0.0143**
	2	33060	0.0377**	0.0159**	0.0252**
Herd production level, kg Poziom wydajności stada, kg	≤7001	34869	0.0281**	–0.0007	0.0035
	7000–9000	36708	0.0372**	0.0021	–0.0025
	>9000	17168	0.0645**	0.0362**	0.0359**
Lactation period, days Okres laktacji, dni	≤60	35022	0.0071	–0.0036	0.0121*
	61–90	27047	0.0165**	0.0189**	0.0307**
	91–120	15199	0.0160*	0.0171*	0.0341**
	121–150	7638	0.0037	0.0125	0.0339**
	151–180	3839	0.0317*	0.0357*	0.0471**
Daily milk yield, kg Wydajność dobowa, kg	≤20	14725	0.0326**	0.0015	–0.0019
	20.1–30.0	40219	0.0329**	–0.0033	–0.0002
	30.1–40.0	25064	0.0392**	–0.0087	0.0002
	>40	8737	0.0266*	–0.0080	0.0039
Season of insemination Sezon inseminacji	Winter/Zima	20384	0.0327**	0.0248**	0.0450**
	Spring/Wiosna	24811	0.0226**	0.0060	0.0246
	Summer/Lato	21339	0.0430**	0.0092	0.0098
	Autumn/Jesień	22211	0.0325**	–0.0048	–0.0014
Herd size (cows) Wielkość stada	≤20	14976	0.0251**	–0.0040	–0.0003
	21–50	32270	0.0313**	–0.0007	–0.0081
	51–200	20691	0.0418**	–0.0019	–0.0024
	>200	20808	0.0292**	–0.0202**	–0.0229**

Significance marked as **P < 0.01, *P < 0.05
Istotność oznaczono jako **P < 0,01, *P < 0,05

mination) and increased slightly in the final stage, assuming positive values. The opposite trend was observed by the above cited authors for nonreturn rate up to 56 days after insemination and for first insemination success. In this case, the initial stage of lactation was characterized by positive coefficients of correlation, which remained near zero in mid-lactation and assumed negative values afterwards. In general, the magnitude of these correlations was considered moderate (values between 0.2 and 0.6). Unlike the above correlation, that between milk urea level and length of RRP throughout lactation was weak (from –0.06 to 0.14) and relatively constant compared to those mentioned above. This suggests the beneficial effect of the higher urea level in early lactation on fertility. Variation in time of the magnitude of genetic correlations between milk urea level and reproductive parameters was also noted by Mucha and Strandberg [2011]. They showed that in early lactation, the correlations between urea content and length of RRP, CI, SP and SPC varied from around zero to –0.1 and increased with advancing lactation while assuming negative values. The same trend was observed for CI, but the correlation coefficient changed from 0.20 to –0.22. As regards the correlation between milk urea level and first insemination success, the authors observed an opposite trend in relation to the other parameters under comparison. With the passage of time after calving, the magnitude of this correlation increased and changed direction (from –0.1 to 0.2). Contradictory results to those of Rzewuska and Strabel [2014] were reported by König et al. [2008], who estimated the coefficient of correlation between length of reproductive rest period and the mean urea level in milk from the first two test-day yields to be 0.29.

Another factor considered when estimating the correlations was the daily milk yield class. In each daily yield class, the relationships between milk urea level and length of CI were statistically significant. No significant correlations were observed between milk urea level and the length of SP and SPC. Positive correlations were noted between milk urea level and the length of CI. The lowest value (0.03**) of the correlation coefficient occurred in the yield class >40 kg; in the lower classes, it remained at a similar level and tended to increase slightly in the higher yield classes. According to Buckley et al. [2003], daily milk yield, especially >29 kg, had an adverse effect on first insemination success.

The season of first insemination caused differences in the coefficients of correlation between milk urea level and CI. As regards the relationships for SP and SPC, significant values were only found in the winter period (r = 0.02** and r = 0.05**, respectively); for CI, all the correlations were significant, assuming the lowest value (r = 0.02**) in spring and the highest value (r = 0.04**) in summer. Sawa et al. [2011] also noted significant correlations between milk urea level and length of CI depending on the season of first insemination. All the values obtained were positive and in the 0.03–0.05 range; the strongest correlations were noted from February to April, and the weakest from November to January, which was attributed to the unfavoruable effect of heat stress on both the urea level and the physiological processes related to reproduction. Interesting conclusions were reached by Melendez et al. [2000] who speculated that the high urea level in milk may be synergistic with the negative impact of heat stress or has a direct negative effect on the physiological process of reproduction. Furthermore, energy expenditure on urea synthesis may increase due to thermal stress. After analysing and excluding all additional factors, the authors of the study found that cows exposed to high urea levels (>160 $mg \cdot l^{-1}$) from day 1 to day 30 before the first insemination, and fertilized during the summer months, are at a much higher risk of not conceiving in comparison with cows with low milk urea levels that had been inseminated in the winter months.

Analysis of the effect of herd size on the coefficients of correlation between urea level and cow fertility showed that for CI, the magnitude of correlations increased from r = 0.03** to r = 0.04** with the number of cows in herd increasing to 200, and decreased to r = 0.03** in herds with >200 cows; in the case of SP and SPC, significant correlations occurred only in herds with >200 cows.

CONCLUSIONS

In conclusion, the increase in milk urea level contributed to prolonging the calving interval (r = 0.03**) and service period (r = 0.01**), as well as to increasing the number of inseminations per conception (r = 0.02**). Therefore, it would be beneficial to monitor dairy herds for milk urea level which could contribute to improving cow fertility. The direction and magnitude of the relationships (expressed as correlation values) between milk urea level and fertility varied within classes of cow's age, lactation period, season of first insemination, milk production level, and herd size.

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OKREŚLENIE ZALEŻNOŚCI MIĘDZY POZIOMEM MOCZNIKA W MLEKU A WYBRANYMI CECHAMI PŁODNOŚCI U KRÓW RASY HOLSZTYŃSKO-FRYZYJSKIEJ

STRESZCZENIE

Na podstawie 88745 próbnych udojów (przeprowadzonych do 30 dni przed pierwszą inseminacją) uzyskanych od 55685 krów rasy polskiej holsztyńsko-fryzyjskiej, oszacowano wartości współczynników korelacji prostej między poziomem mocznika w mleku, a wybranymi wskaźnikami płodności, wiekiem krów, poziomem wydajności, wielkością stada, sezonem pierwszej inseminacji i okresem laktacji. Stwierdzono, że wzrost poziomu mocznika w mleku wpływał istotnie ($P \leq 0{,}01$) na wydłużenie OMW (r = 0,03) i OU (r = 0,01), a także zwiększenie liczby inseminacji potrzebnych do zacielenia krowy (r = 0,02). Kierunek i siła zależności (wyrażonej wartościami współczynnika korelacji) między poziomem mocznika w mleku a płodnością okazały się zróżnicowane w obrębie klas wybranych czynników jak wiek krów, okres laktacji, sezon pierwszej inseminacji, poziom wydajności i wielkość stada. Badania wykazały, że w stadach krów mlecznych rasy polskiej holsztyńsko-fryzyjskiej korzystne byłoby monitorowanie poziomu mocznika w mleku, co mogłoby przyczynić się do poprawy płodności krów.

Słowa kluczowe: krowy mleczne, rasa holsztyńsko-fryzyjska, poziom mocznika w mleku, korelacje, płodność