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EFFECT OF DAILY YIELD OF COWS AND DATE OF FIRST INSEMINATION ON SERVICES PER CONCEPTION

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ABSTRACT

This study analysed the effect of daily milk yield (28 078 test-day measurements recorded up to 30 days before first insemination, during the period up to 150 days of the first and second lactation), season of first insemination and reproductive rest period on fertility of 17 618 cows measured as number of services per conception. Data were analysed using the GLM and FREQ procedures of the SAS package. The number of inseminations needed for pregnancy increased with increasing daily milk yield of the cows, especially when the first insemination was performed in summer or when reproductive rest period was shortened to $\leq$60 days after calving.

Key words: cows, services per conception, daily milk yield, insemination date

INTRODUCTION

Declining fertility in dairy cows is a growing problem despite the popularization of different methods of estrous cycle control, induction of ovulation, therapeutic agents, and insemination at a fixed time [Jaśkowski et al. 2006]. This problem has been attributed to improper nutrition, negative energy balance, inadequate body condition, heat stress and, in particular, increasing milk yields [Jaśkowski et al. 2005; 2006, Bogucki et al. 2007, Wiltbank et al. 2008, Januś and Borkowska 2010, Kowalski 2010, Jankowska et al. 2012, Czerniawska-Piątkowska and Gajdka 2014,]. According to Januś and Borkowska [2006], the unfavourable correlations between milk yield and fertility can be explained by post-calving insemination date, which usually occurs at the peak of lactation. A negative energy balance is more frequent during this period, which blocks the secretion of luteinizing hormone, inhibits the development of ovarian follicles, and delays ovulation. It also indirectly affects the production and secretion of progesterone, which regulates the onset of estrus signs and embryo implantation [Butler 2000, Bogucki et al. 2007]. Previously, it was believed that the reproductive cycle of the cow should last up to 12 months due to cow feeding costs and number of calves born per year. According to Hibner et al. [1999], a calving interval of one year may contribute to difficulties in drying off the cows and preparing them for the next lactation. It is increasingly recommended that the reproductive cycle of the cows be extended to 15–18 months to reduce culling rates, improve herd fertility and health, and significantly increase milk yields [Bogucki et al. 2007]. Januś and Borkowska [2010] observed the reproductive rest period of cows inseminated in summer and spring to increase as a result of adverse variations in temperature. Especially high milk-producing cows have poorer adaptability to heat stress. This increases the risk of temporary infertility in cattle [Jaśkowski et al. 2005, Bodstedt and Boryczko 2011]. Another frequent outcome is the incidence of conditions such as acyclicity and anestrus, because weakened cows are more vulnerable to negative factors that impair immunity and body functions [Max 2010].

The objective of the study was to analyse the effect of daily milk yield, season of first insemination, and reproductive rest period (RRP) on fertility of cows measured as number of services per conception (SPC).

MATERIAL AND METHODS

The experimental data were extracted from the SYMLEK database belonging to the Polish Federation of Cattle

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Breeders and Dairy Farmers. Analysis included 28 078 test-day yields of 17 618 Polish Holstein-Friesian cows of Black-and-White variety, which belonged to the active population in Pomerania and Kuyavia. The cows first calved during 2011-2014 and were used until the end of 2015.

The following data were gathered for each cow:

- date of first, second and third calving,
- date of first inseminations in the first and second reproductive cycle,
- daily milk yield from test-day measurements recorded up to 30 days before first insemination, during the period up to 150 days of the first and second lactation,
- services per conception – number of inseminations required to conceive.

The GLM procedure of the SAS package was used for statistical calculations according to the following linear model [SAS 2014]:

$$Y = \mu + a_i + b_j + (ab)_{ij} + (ac)_{ik} + e_{ij}$$

where:
μ – overall mean,
a_i – effect of i-th daily yield group in test-day measurement recorded up to 30 days before first insemination ($\leq$20; 20.1–30; 30.1–40; and > 40 kg milk),
b_j – effect of j-th season of first insemination (spring: March–May, summer: June–August, autumn: September–November, winter: December–February),
c_k – effect of k-th lactation period ($\leq$60, 61–90, >90 days),
$(ab)_{ij}$ – interaction between daily yield and season of first insemination,
$(ac)_{ik}$ – interaction between daily yield and lactation period,
e_{ij} – random error of observation.

Significance of differences was determined with the Scheffe test.

The CORR procedure [SAS 2014] was used to calculate the coefficients of simple correlation between daily yield in test-day measurement recorded up to 30 days before first insemination and number of services per conception, taking into account the effect of season of first insemination and reproductive rest period.

RESULTS

Average daily milk yield was 30.3 kg. The increasing daily yield, from $\leq$20 kg to >40 kg milk, had an adverse effect on cow fertility and the number of services per conception increased by 0.3 ($P \leq 0.01$) (Table 1), which indicates that milk yield should be considered when making decisions about reproduction. The effect of daily milk yield varied more with the reproductive rest period than with the season of the year. The number of services per conception averaged 2.03. SPC value varied greatly when the first insemination was performed during 61–90 days of lactation, and increased from 1.8 to 2.2 with the increasing daily milk yield. When the first insemination was performed up to day 60 of lactation, the number of semen doses per conception of cows with a milk yield between $\leq$20 kg and >40 kg differed by 0.17. This may suggest that the problems experienced in practice to achieve a pregnancy in the early lactation period do not stem directly from the high milk yield of the cows. In seeking practical solutions, attention should be called to a number of other factors, including those related to herd management.

As expected, the increasing lactation period was paralleled by a decrease in the number of semen doses per conception. Cows inseminated before day 60 of lactation, compared to their contemporaries inseminated later, were characterized by a significantly higher number of services per conception (by 0.35). The greatest differences at $P \leq 0.01$ (0.45) were observed in the group of cows with lowest daily milk yield ($\leq$20 kg).

The effect of daily milk yield on fertility also varied according to the season of first insemination (Table 2). The increase in daily milk yield was paralleled by declining fertility, especially when the first insemination was performed in the summer and autumn season (SPC higher by 0.37). When the first insemination was carried out in winter and spring, variation in SPC was lower and approximated 0.23 between cows with lowest and highest daily milk yield. It may be noted that the effect of the season of first insemination on cow fertility increased with increasing daily milk yield. While the number of services per conception in cows with a daily milk yield $\leq$20 kg did not vary according to the season of first insemination, the cows with a daily milk yield >30 kg showed poorer fertility (around 0.25 and 0.30 more inseminations per conception) after summer compared to autumn inseminations.

The coefficients of correlation (Table 3) confirm the previously reported tendency for the number of inseminations per conception to increase with the increasing daily milk yield of the cows. When analysing the magnitude of correlations between daily yield and fertility of the cows in different lactation periods, in which the first insemination was performed, it was found that the correlations for the number of services per conception were statistically significant ($P \leq 0.01$) regardless of the lactation period, and reached the highest values for 61–90 and >90 days of

Table 1. Number of services per conception depending on daily milk production level, lactation period and insemination season

Tabela 1. Wartość indeksu inseminacji w zależności od poziomu wydajności dobowej mleka, okresu laktacji I sezonu inseminacji

Factor, range Czynnik, zakres			Daily milk yield, kg – Wydajność dobowa, kg									
			≤ 20		20.1 – 30		30.1 – 40		> 40		Total – Ogółem	
Total – Ogółem			n	II	n	II	n	II	n	II	n	II
			3042	1.88 AB	11669	1.96 CD	9607	2.04 ACE	3760	2.18 BDE		
Lactation period, days Okres laktacji, dni	≤ 60	1	985	2.15	4871	2.12	4305	2.20	1749	2.32	11910	2.20
	61 – 90	2	891	1.80	3673	1.95	3177	2.04	1315	2.20	9056	2.00
	> 90	3	1166	1.70	3125	1.80	2125	1.87	696	2.02	7112	1.85
												1–2.3[xx]
												2–3[xx]
Season of first insemination Sezon pierwszej inseminacji	XII – II	1	693	1.82	2548	1.90	2185	1.96	876	2.04	6302	1.93
	III – V	2	653	1.89	3158	1.96	2870	2.02	1109	2.14	7790	2.00
	VI – VIII	3	689	1.97	2752	2.09	2327	2.21	998	2.34	6766	2.15
	IX – XI	4	1007	1.85	3211	1.88	2225	1.96	777	2.22	7220	1.98
												2–1.3.4[xx]

The same capital letters indicate significant differences between values in a row (p≤ 0.001).
[xx] significant differences in columns (p≤0.001).
Tymi samymi dużymi literami oznaczono istotność pomiędzy wartościami w wierszu (p≤ 0,001).
[xx] oznaczono istotność w kolumnach (p≤0,001).

Table 2. Number of observations for services per conception depending on daily milk production level, lactation period and insemination season

Tabela 2. Liczebność obserwacji dla wartości indeksu inseminacji w zależności od poziomu wydajności dobowej mleka, okresu laktacji I sezonu inseminacji

Factor, range Czynnik, zakres			Daily milk yield, kg Wydajność dobowa, kg				
			≤ 20	20.1–30	30.1–40	> 40	Total
Lactation period, days Okres laktacji, dni	≤ 60	1	985	4871	4305	1749	11910
	61–90	2	891	3673	3177	1315	9056
	> 90	3	1166	3125	2125	696	7112
Season of first insemination Sezon pierwszej inseminacji	XII–II	1	693	2548	2185	876	6302
	III–V	2	653	3158	2870	1109	7790
	VI–VIII	3	689	2752	2327	978	6766
	IX–XI	4	1007	3211	2225	777	7220
Total – Ogółem			3042	11669	9607	3760	

lactation (r = 0.07999[xx] and r = 0.07556[xx]). In the case of the cows inseminated up to day 60 of lactation, this correlation was slightly lower (r = 0.03488[xx]). Analysis of the effect of the season of first insemination on the relationships between daily milk yield and services per conception showed that the coefficients of correlation assumed positive values. The correlations were higher in summer and autumn (around r = 0.08[xx]) than in winter and spring (around r = 0.05[xx]).

DISCUSSION

The increasing number of services required to conceive with the increasing milk yield of the cows demonstrated in the present study, is in agreement with the literature reports [Januś and Borkowska 2006, Czerniawska-Piątkowska and Gajdka 2014]. In the study by Bogucki et al. [2007], the number of services per conception increased with increasing milk yield and averaged 1.77 for <6,000 kg and 3.61 for >14,000 kg milk yield. Similar tendencies were reported by Miciński [2007], Januś and Borkowska [2010]. According to Januś and Borkowska [2006], a 500–700 kg increase in milk yield per standard lactation requires around 3 more inseminations per conception. This may be due to difficulties in meeting the high nutrient requirements of cattle during the early lactation period. High amounts of energy are needed to achieve high sexual activity. After calving, a cow utilizes

most of the nutrients for maintenance and milk production, rather than for the next sexual cycle or to carry out a new pregnancy. This is the case of fertility competing with milk yield [Butler 2000].

Table 3. Coefficients of simple correlation between daily milk yield and services per conception depending on season and period of first insemination

Tabela 3. Wartości współczynników korelacji prostej między wydajnością dobową mleka a indeksem inseminacji w zależności od sezonu I okresu przeprowadzenia pierwszej inseminacji

Factor – range Czynnik – zakres		n	r
Total – Ogółem		28078	0.06878^{xx}
Lactation period, days Okres laktacji, dni	≤ 60	11910	0.03488^{xx}
	61–90	9056	0.07999^{xx}
	>90	7112	0.07556^{xx}
Season of first insemination Sezon pierwszej inseminacji	XII–II	6302	0.05784^{xx}
	III–V	7790	0.05286^{xx}
	VI–VIII	6766	0.08043^{xx}
	IX–XI	7220	0.07493^{xx}

^{xx} significant at p≤0.001
^{xx} istotność (p≤0,001)

The specialized literature gives differing opinions about the optimum reproductive rest period of cows. According to Stevenson [2001], the first insemination should take place within 40–70 days of calving. Juszczak and Hibner [2000] consider insemination of cows before day 60 of lactation as negative and harmful. According to Kruszyński and Pawlina [2011], extending the reproductive rest period beyond 90 days will make the insemination much more effective. Krzyżewski and Reklewski [2003] recommend that postpartum insemination should begin around 110 days of lactation. In our study we found the number of services per conception to decrease with the increasing time from last calving to first insemination, and most of the differences were statistically significant. This may be explained by the fact that first insemination success increases as calving date moves further away [Řehák et al. 2009]. The correlation between the number of services per conception and the lactation period coinciding with first insemination was also highlighted by Rzewuska and Strabel [2014]. Likewise, Yusuf et al. [2011] observed a positive effect of insemination date moving further away from parturition on the number of services per conception, which ranged from 1.9 to 2.4, noting the highest values in the early stages of lactation (up to day 60), which is in line with our findings. Also research in Sweden [Lomander et al. 2013] shows that early insemination of cows after calving (<60 days) results in a greater number of services per conception; accordingly, the authors recommend postponing the inseminations to make them more effective. Max [2010] reports that the reproductive system should regenerate, and cyclic ovarian function should be restored between 30 days and 8 weeks after calving. According to Miciński [2007], due to the annually increasing milk yield of the cows, the interpregnancy interval of 120–160 days is slowly becoming accepted, and higher yielding cows are simply suited to extended lactations.

In our study, the magnitude of the correlation between daily milk yield and the number of services per conception tended to increase as the date of first insemination moved further away from calving (Table 3). Japanese studies [Hagiya et al. 2013] showed a negative effect of cow's milk yield on first insemination success. For both primiparous and second-lactation cows, negative phenotypic correlations were noted and their values increased with advancing lactation (r = –0.024 to r = –0.215 for primiparous cows and r = –0.010 to r = –0.207 for second-lactation cows).

Our study showed a tendency for the number of semen doses required for conception to increase when the first inseminations were performed in summer (June–August) (Table 1). Likewise, Nogalski [2006] reported that summer inseminations had a negative effect on insemination success. This is known as the summer infertility syndrome [Jaśkowski et al. 2006]. According to Jaśkowski et al. [2005], high yielding cows show poor adaptation to heat stress conditions. Similar results were obtained by Jankowska et al. [2012]. High ambient temperatures contribute to lower feed intake [Rzewuska and Strabel 2015], resulting in a negative energy balance and associated major hormonal changes. It should also be remembered that heat stress may have a long-term effect. Because the ovarian follicle growth takes a period of 3 to 4 months [Crowe et al. 2014], the abnormalities occurring in the initial stages may appear long afterwards.

CONCLUSION

In summary, it is concluded that the number of services per conception depended on both daily milk yield of the cows and the season and date of first insemination after calving. The number of inseminations needed for pregnancy increased with increasing daily milk yield of the cows, especially when the first insemination was performed in summer or when reproductive rest period was shortened to ≤60 days.

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WPŁYW WYDAJNOŚCI DOBOWEJ KRÓW I TERMINU PIERWSZEJ INSEMINACJI NA INDEKS INSEMINACJI

STRESZCZENIE

Analizowano wpływ wydajności dobowej (28078 próbnych dojów przeprowadzonych do 30-tu dni przed pierwszą inseminacją, w okresie do 150 dnia pierwszej i drugiej laktacji), sezonu pierwszej inseminacji oraz długości okresu spoczynku rozrodczego na płodność 17618 krów mierzoną indeksem inseminacji. W obliczeniach statystycznych zastosowano procedurę GLM oraz FREQ z pakietu SAS. Wykazano zwiększanie liczby zabiegów potrzebnych do zacielenia krowy wraz ze wzrostem ich wydajności dobowej, szczególnie, gdy pierwsza inseminacja była wykonywana latem lub gdy okres spoczynku rozrodczego skrócono do $\leq$60 dni od wycielenia.

Słowa kluczowe: krowy, indeks inseminacji, wydajność dobowa mleka, termin inseminacji