ACTA SCIENTIARUM POLONORUM

Acta Sci. Pol. Zootechnica 16(4) 2017, 33–38

www.asp.zut.edu.pl pISSN 1644-0714 eISSN 2300-6145 DOI:10.21005/asp.2017.16.4.05

ORIGINAL PAPER

Received: 28.06.2017
Accepted: 24.11.2017

ANALYSIS OF THE RELATIONSHIP BETWEEN SOMATIC CELL COUNT AND FERTILITY IN HOLSTEIN-FRIESIAN COWS

Weronika Kulpa, Anna Sawa✉, Małgorzata Jankowska

Department of Animal Science, Unit of Cattle Breeding, UTP University of Science and Technology, Mazowiecka 28, 85-084 Bydgoszcz, Poland

ABSTRACT

Somatic cell counts (SCC) in milk from test-day records obtained until 30 days before the first service were analyzed in relation to service efficacy, calving interval (CI), days open (DO) and services per conception rate (S/C). Statistical analysis (GLM, FREQ, CORR of the SAS package) involved 28,078 test-day records from 17,618 HF cows, which calved between 2011–2014. Significant ($P \leq 0.001$) correlations were found between SCC and the fertility indices. First service successful conception was found to decrease by approx. 6% with an increase in SCC in milk. Increased SCC was accompanied by an extended calving interval (by 3 days) and days open (by 6 days), as well as by an increased S/C rate, from 1.99 in cows with SCC <100,000 cells $\cdot$ ml^{-1} to 2.03 in cows with SCC >1,000,000 cells $\cdot$ ml^{-1}. This relationship was confirmed by positive coefficients of correlation between SCC vs. CI, DO and S/C. Dairy cattle producers should monitor SCC in milk, also because its possible increase may have a detrimental effect on the overall fertility of the herd.

Key words: dairy cows, somatic cell count, fertility, Holstein-Friesian cows

INTRODUCTION

Somatic cell count (SCC) is a parameter of milk which reflects the health status of the cows, but also is a measure of the cytological and technological quality of milk, determining its fate in terms of further processing. More and more increasingly, however, infections have been discussed in relation to reproductive diseases [Skrzypek et al. 2007]. Udder infections and fertility disorders disrupt the hormonal and immunological systems of the cow. In consequence, deviations in ovulation and estrous cycle timing occur and increased embryonic mortality is the case [Skrzypek et al. 2007]. Cows with high SCCs exhibit poorer expression of heat, and the cycles are also disturbed [Nguyen et al. 2011, Morris et al. 2013, Kumar et al. 2017]. Clinical mastitis negatively affects the levels of progesterone, prolactin, LH, FSH or immunoglobulins in the body. Subclinical mastitis cases, on the other hand, particularly those intensifying during the heat, lead to an increase in estrogen levels, which consequently reduce the ability of somatic cells to phagocytosis [Skrzypek et al. 2007]. Higher SCCs in milk also results in higher concentrations of PGF2α, which leads to higher miscarriage rates and prolonged calving-to-conception periods [Rekik et al. 2008]. Hudson et al. [2012] demonstrated that an outbreak of mastitis reduced pregnancies and the general fertility of cows. According to Sawa et al. [2010], cows with a low SCC (below 100,000 cells/ml) exhibit better fertility compared to cows suffering from mastitis. Skrzypek et al. [2007] point out that udder diseases most affect the reproduction functions in the peri-estral period and at early embryonic stages. The authors also stress that SCC should be checked before the first service post-partum. Morris et al. [2013] emphasize that the situation of subclinical mastitis preceding its clinical form has a negative effect on reproduction. Nava-Trujillo et al. [2010] claim that both forms of mastitis are detrimental to fertility, however, subclinical mastitis makes the situation even worse. Kumar et al. [2017] demonstrated that cows with a single mastitis episode exhibited a prolonged resting period, whereas those with recurring mastitis had a higher services per conception rate.

A high number of somatic cells in milk in the periparturient period adversely affects the fertility of cows, and – in particular – causes an increase in the value of S/C

✉sawa@utp.edu.pl

[Olechnowicz and Jaśkowski 2013]. Research [Skrzypek et al. 2007, Nava-Trujillo et al. 2010, Hudson et al. 2012] showed that the time of occurrence of mastitis affects the reproduction of cows differently. In the studies conducted by Gunay and Gunay [2008], Nava-Trujillo et al. [2010] and Kumar et al. [2017] a negative effect of udder inflammation diseases at the first estrus was found, which resulted in a significant elongation of resting period duration and days open period. Kumar et al. [2017] showed that in cows diagnosed with clinical mastitis before and after service the resting period was prolonged and the value of S/C increased in relation to healthy cows. According to Juozaitien and Juozaitis [2005], there is a risk of miscarriage in consequence of mastitis occurring after confirmation of conception.

Many authors [Skrzypek et al. 2007, Pinedo et al. 2009, Sawa et al. 2010, Olechnowicz and Jaśkowski 2013] agree that a low milk SCC is accompanied by the best fertility parameters. Hudson et al. [2015], on the other hand, state that improving the health status of the udders at the level of the herd will not cause any noticeable changes in the reproduction of cows.

The aim of the study was to determine the degree of relationship between somatic cell counts in milk and selected fertility indicators of Holstein-Friesian cows.

MATERIAL AND METHODS

The analysis was carried out using milk somatic cell count (SCC) data from the SYMLEK database, which involved 28,078 test-day records of 17,618 Polish Holstein-Friesian Black-and-White cows belonging to the population active in Pomerania and Kujawy, Poland, first calving in 2011–2014 and remaining in production until the end of 2015. The test days had been carried out up to 30 days prior to first service, up to 150 days in the first and second lactation. Because SCC is characterized by high variability and does not have a normal distribution, transformation was performed using the natural logarithm (LnSCC). The following fertility parameters were taken into account: the number of services, calving interval (CI), days open (DO), services per conception (S/C).

We used the chi-square test [SAS 2014] to derive the proportion of cows pregnant after the first service in relation to milk SCC in the test-day record obtained 30 days prior to the service.

The following linear model was used to evaluate the effect of SCC on the remaining fertility parameters [SAS 2014]:

$$Y = \mu + a_i + e_{ij}$$

where:

μ – total mean,

a_i – effect of the i-th level of SCC in 1 ml of milk ($\leq$100,000; 100,001–200,000; 200,001–400,000; 400,001–500,000; 500,001–1,000,000; >1,000,000),

e_{ij} – random error.

The Scheffe test was used to test the significance of differences. Also, the CORR procedure [SAS 2014] was used to compute linear correlation coefficients between milk SCC (lnSCC) of the test-day record collected up to 30 days prior to the first service and selected fertility parameters.

RESULTS AND DISCUSSION

The efficiency of the first service was 46.98% (Table 1), which is a sign of poor fertility of the analyzed cows [Mordak 2008]. The rate of successful services declined significantly ($P \leq 0.001$) with an increase in SCC. First service efficiency in cows with milk SCCs higher than 1 million cells/ml was by 6% lower compared with healthy cows. Reports by numerous authors [Sawa et al. 2010, Yang et al. 2012, Albaaj et al. 2017, Bouamra et al. 2017] confirm this relationship. Sawa et al. [2010] demonstrated a 2% decrease in successful services in cows suffering from mastitis.

Table 1. Effectiveness of the first insemination depending on the level of SCC in milk samples

Tabela 1. Liczba komórek somatycznych w mleku a skuteczność pierwszej inseminacji

SCC in 1 ml of milk LKS w 1 ml mleka	Number of milk samples N próbek mleka	Insemination Inseminacja $chi^2 = 45.7^{xx}$	
		Ineffective, % Nieskuteczna, %	Effective, % Skuteczna, %
≤100,000	14,963	51.74	48.26
100,001–200,000	4,676	52.42	47.58
200,001–400,000	3,149	53.48	46.52
400,001–500,000	758	55.15	44.85
500,001–1,000,000	1,802	57.10	42.90
>1,000,000	2,542	57.59	42.41
Total	27,890	53.02	46.98

^{xx} ($P \leq 0.001$).

Albaaj et al. [2017], who carried out analyses in France, reports that the more severe the disease, the lower the chance of conception. In Venezuela, on the other hand, insemination efficiency was 56.1%, in mastitis-affected cows, vs. 49.72%, in healthy animals [Nava-Trujillo et al. 2010]. The studies carried out in Algeria [Bouamr et al. 2017] revealed that cows with clinical mastitis were characterized by a lower service success compared to healthy cows, regardless of the time when the disease appeared. In cows with mastitis, the index was 38.7% before the first insemination, in cows

with mastitis between insemination and pregnancy confirmation 33.3%, while in cows from the control group 61.39%. According to Yang et al. [2012], effectiveness of the first service in mastitis-affected cows before and after insemination was 36.5%, whereas in healthy cows 54.9%. Also the results by other authors [Juozaitien and Juozaitis 2005, Gunay and Gunay 2008, Olechnowicz and Jaśkowski 2013, Kumar et al. 2017] showed that cows with mastitis were characterized by a higher services per conception rate in relation to cows free of mastitis.

The average calving interval in the analyzed group was 407 days (Table 2) and was lower than that for the Polish population of H-F cattle in 2015 (432 days) and 2016 (431 days) [PFHBiPM 2016, 2017]. Days open in the studied population of cows averaged 42 days, whereas the amount of semen used for a conception was 2.03 doses. It was found that cows with low somatic cell count in milk ($\leq$100,000 cells $\cdot$ ml^{-1}) were characterized by better fertility: CI was shorter by 10 days, DO by 6 days, and S/C lower by 0.14, compared to the group of cows with SCC above 1,000,000 cells $\cdot$ ml^{-1} of milk. The results of numerous studies conducted in various regions of the world confirm the negative effect of mastitis on the fertility of cows [Juozaitiene and Juozaitis 2005, Skrzypek et al. 2007, Gunay and Gunay 2008, Rekik et al. 2008, Ahamadzadeh et al. 2009, Pinedo et al. 2009, Sawa et al. 2010, Nguyen et al. 2011, Hudson et al. 2012, Yang et al. 2012, Chegini et al. 2016, Kumar et al. 2017].

Table 2. Relationship between milk SCC and selected fertility indices

Tabela 2. Wpływ liczby komórek somatycznych w mleku na długość OMW i OU oraz wartość II

SCC in 1 ml of milk LKS w 1 ml mleka	The values of fertility indices Wartości wskaźników płodności		
	Calving interval, days OMW, dni	Days open, days OU, dni	Services per conception (S/C) II
≤100,000	404^{ABC}	41	1.99^{A}
100,001–200,000	407	42^{A}	2.04
200,001–400,000	411^{A}	43	2.04
400,001–500,000	411	45	2.11
500,001–1,000,000	411^{B}	44	2.11
>1,000,000	414^{C}	47^{A}	2.13^{A}
Average – Średnia	407	42	2.03

Same capital letters denote significance between values in columns ($P \leq 0.001$).
Tymi samymi dużymi literami oznaczono istotność pomiędzy wartościami w kolumnach ($P \leq 0{,}001$).

Ahamadzadeh et al. [2009] analyzed dairy cows herds in the USA and found an increase in S/C rate by about 0.5 in cows suffering from mastitis, compared to healthy cows, and if mastitis was accompanied by another disease, this indicator was higher by another 0.7. Research on a population of dairy cows in Algeria confirmed that the time of occurrence of mastitis exerted a negative influence on the value of the insemination index. Cows diagnosed with mastitis in the period from insemination to confirmation of pregnancy needed more services per conception than cows in which mastitis occurred before insemination [Bouamra et al. 2016]. Studies carried out in Iran have also shown an extension of CI by 49 days and an increase in tS/C by 0.45 in cows with clinical mastitis, in relation to healthy cows, with mastitis having a stronger negative impact on high yielding cows [Chegini et al. 2016]. Kumar et al. [2017], who analysed a cow population in India, paid particular attention to the fact that cows with severe mastitis needed more services to conceive, compared to cows with a mild form of this disease. Additionally, the authors emphasize that cows with frequently recurring mastitis were characterized by a higher S/C index than those with a single episode or healthy. Also Fuenzalida et al. [2015] consider that the subclinical form of mastitis may affect reproduction in cows, and the magnitude of this effect increases with the intensity of inflammation. Pinedo et al. [2009] investigating a cow herd in Chile confirm that cows with higher SCC in milk had 0.44 higher S/C rates as opposed to healthy cows. They also demonstrated an extension of calving-to-conception period and reproductive resting period by 49 and 21 days in, respectively, healthy and sick cows. Sawa et al. [2010] showed that cows with clinical mastitis had CI by 13 days longer and S/C by 0.1 higher in relation to healthy cows.

On the other hand, research done in Sweden and China did not show the effect of high SCCs in milk on the fertility of cows [Yang et al. 2012, Lomander et al. 2013]. Similarly, studies carried out in Venezuela by Nava-Trujillo et al. [2010] do not show any relationship between SCC and S/C, which was 2.21 in healthy and 2.35 in mastitis-affected cows. Gunay and Gunay [2008] also found no significant effect of mastitis on the amount of semen used for insemination. However, they note that poorer reproduction parameters (including higher rates of S/C) were characteristic for cows with mastitis between the first service and pregnancy diagnosis, than those that fell ill after service or remained healthy.

Statistically significant ($P \leq 0.001$) positive correlations have been found between somatic cell counts in milk and selected indicators of fertility in cows (Table 3). Thus, it can be concluded that the increase in SCC in milk was accompanied by an increase in the time between first and effective service (DO), more semen was used for calving (S/C), and consequently the calving interval (OMW) was longer. Our results are consistent with the results of other authors [Juozaitiene and Juozaitis 2005, Skrzypek et al. 2007, Sawa et al. 2010]. Juozaitiene and Juozaitis [2005] state that the values of correlation coefficients between SCC and CI, DO and S/C fluctuated

in the range 0.36^{xx}–0.44^{xx}. Sawa et al. [2010] showed a positive correlation ($r = < 0.2^{xx}$) for CI and S/C. On the other hand, Skrzypek et al. [2007] found a relationship between 0.12 and 0.14 for S/C, depending on the herd. In contrast, studies conducted in the United Kingdom showed a negative correlation between mastitis and CI and S/C [Kadarmideen et al. 2000].

Table 3. Coefficients of correlation between SCC, LnSCC and CI, DO, S/C

Tabela 3. Wartości współczynnków korelacji między LKS i LnLKS a OMW, OU i II

Somatic cells Komórki somatyczne	Calving interval (CI) OMW	Days open (DO) OU	Services per conception (S/C) II
SCC	0.05128^{xx}	0.03030^{xx}	0.03514^{xx}
LnSCC	0.06069^{xx}	0.03749^{xx}	0.04018^{xx}

^{xx} ($P \leq 0.001$).

CONCLUSIONS

The effectiveness of the first service decreased with an increase in the number of somatic cells present in milk. With an increase in SCC, calving interval (CI) and days open (DO) increased and services per conception index (S/C) increased too. Positive correlations between the number of somatic cell counts in milk and selected fertility parameters, despite being low, were statistically significant. Dairy farmers should pay attention to an increase in SCC in milk, also due to their deteriorating effect on cow fertility.

REFERENCES

Ahamadzadeh, A., Frago, F., Shafii, B., Dalton, J.C., Price, W.J., McGuire, M.A. (2009). Effect of clinical mastitis and other diseases on reproductive performances of Holstein cows. Anim. Reprod. Sci., 112, 273–282.

Albaaj, A., Foucras, G., Raboisson, D. (2017). High somatic cell counts and changes in milk fat and protein contents around insemination are negatively associated with conception in dairy cows. Theriogenology, 88, 18–27.

Bouamra, M., Ghozlane, F., Ghozlane, M.K. (2017). Factors affecting reproductive performance of dairy cow in Algeria: Effects of clinical mastitis. Afr. J. Biotechnol., 16(2), 91–95.

Chegini, A., Ghavi Hossein-Zadeh, N., Hosseini-Moghadam, H., Shadparvar, A.A. (2016). Factors affecting clinical mastitis and effects of clinical mastitis on reproductive performance of Holstein cows. Revue Méd. Vét., 167, 5–6, 145–153.

Fuenzalida, M.J., Fricke, P.M., Ruegg, P.L. (2015). The association between occurrence and severity of subclinical and clinical mastitis on pregnancies per artificial insemination at first service of Holstein cows. J. Dairy Sci., 98(6), 3791–3805.

Gunay, A., Gunay, U. (2008). Effects of clinical mastitis on reproductive performance in Holstein cows. Acta Vet. Brno, 77, 555–560.

Hudson, C.D., Bradley, A.J., Breen, J.E., Green, M.J. (2012). Associations between udder health and reproductive performance in United Kingdom dairy cows. J. Dairy Sci., 95, 3683–3697.

Hudson, C.D., Bradley, A.J., Breen, J.E., Green, M.J. (2015). Dairy herd mastitis and reproduction: Using simulation to aid interpretation of results from discrete time survival analysis. Vet. J., 201, 47–53.

Juozaitiene, V. i Juozaitis, A. (2005). The influence of somatic cell count in milk on reproductive traits and production of Black-and-White cows. Vet. Archiv., 75(5), 407–414.

Kadarmideen, H.N., Thompson, R., Simm, G. (2000). Linear and threshold model genetic parameters for disease, fertility and milk production in dairy cattle. Anim. Sci., 71, 411–419.

Kumar, N., Manimaran, A., Sivaram, M., Kumaresan, A., Jeyakumar, S., Sreela, L., Mooventhan, P., Rajendran, D. (2017). Influence of clinical mastitis and its treatment outcome on reproductive performance in crossbreed cows: A retrospective study. Vet. World, 10(5), 485–492.

Lomander, H., Svensson, C., Hallen-Sandgren, C., Gustafsson, H., Frössling, J. (2013). Associations between decreased fertility and management factors, claw health, and somatic cell count in Swedish dairy cows. J. Dairy Sci., 96(10), 6351–6323.

Mordak, R. (2008). Podstawy monitorowania rozrodu w stadach bydła [Introduction to cattle herd reproduction monitoring]. Życie Weter., 83(9), 736–741 [in Polish].

Morris, M.J., Kaneko, K., Uppal, S.K., Walker, S.L., Jones, D.N., Routly, J.E., Smith, R.F., Dobson, H. (2013). Effects of high somatic cell counts in milk on reproductive hormones and oestrus behaviour in dairy cows with special reference to those with concurrent lameness. Anim. Reprod. Sci., 141, 20–25.

Nava-Trujillo, H., Soto-Belloso, E., Hoet, A.E. (2010). Effect of clinical mastitis from calving to first service on reproductive performance in dual-purpose cows. Anim. Reprod. Sci., 121, 12–16.

Nguyen, T.C., Nakao, T., Gautam, G., Su, L.T., Ranasinghe, R.M., Yusuf M. (2011). Relationship between milk somatic cell count and postpartum ovarian cyclicity and fertility in dairy cows. Acta. Vet. Hung., 59(3), 349–362.

Olechnowicz, J., Jaśkowski, J.M. (2013). A connection between mastitis Turing Early lactation and reproductive performance of dairy cows – a review. Ann. Anim. Sci., 13(3), 435–448.

Pinedo, P.J., Melendez, P., Villagomez-Cortes, J.A., Risco, C.A. (2009). Effect of high somatic cell counts on reproductive performance of Chilean dairy cattle. J. Dairy Sci., 92, 1575–1580.

Polska Federacja Hodowców Bydła i Producentów Mleka w Warszawie – Region Oceny Bydgoszcz, 2016. Wyniki oceny wartości użytkowej bydła mlecznego – dane za rok 2015 [Polish Federation of Cattle Breeders and Milk

Producers in Warsaw – Evaluation Region Bydgoszcz, 2016. Results of dairy cattle evaluation – data for 2016] [in Polish].

Polska Federacja Hodowców Bydła i Producentów Mleka w Warszawie – Region Oceny Poznań, 2017. Wyniki prac hodowlanych w roku 2016 [Polish Federation of Cattle Breeders and Milk Producers in Warsaw – Evaluation Region Poznań, 2017. Results of breeding works in 2016][in Polish].

Rekik, B., Ajili, N., Belhani, H., Ben Gara, A., Ronissi, H. (2008). Effect of somatic cell count on milk and protein yields and female fertility in Tunisian Holstein dairy cows. Livest. Sci., 116, 309–317.

SAS Institute Inc., 2014. SAS/STAT 9.4 User's Guide. Cary, NC: SAS Institute Inc.

Sawa, A., Bogucki, M., Jankowska, M. (2010). Wpływ wybranych czynników na zależności między liczbą komórek somatycznych w mleku a płodnością krów [The influence of selected factors on the relationship between somatic cell counts in milk and the fertility of cows]. Rocz. Nauk. Pol. Tow. Zootech., 6(4), 247–256 [in Polish].

Skrzypek, R., Antkowiak, I., Pytlewski, J. (2007). Zależność między liczbą komórek somatycznych w mleku a wskaźnikami płodności krów [The relationship between somatic cell counts and fertility indices in cows]. Med. Weter., 63(10), 1247–1250 [in Polish].

Yang, F.L., Li, X.S., Yang, B.Z., Zhang, Y., Zhang, X.F., Qin, G.S., Liang, X.W. (2012). Clinical mastitis from calving to next conception negatively affected reproductive performance of dairy cows in Nanning, China. Afr. J. Biotechnol., 11(10), 2574–2580.

OKREŚLENIE ZALEŻNOŚCI POMIĘDZY LICZBĄ KOMÓREK SOMATYCZNYCH A PŁODNOŚCIĄ U KRÓW RASY HOLSZTYŃSKO-FRYZYJSKIEJ

STRESZCZENIE

Analizowano zależności między liczbą komórek somatycznych (LKS) w mleku z próbnych udojów przeprowadzonych do 30 dnia przed pierwszą inseminacją, a jej skutecznością, długością okresu międzywycieleniowego (OMW), okresu usługi (OU) i wartością indeksu inseminacji (II). W opracowaniu statystycznym (GLM, FREQ, CORR z pakietu SAS) wykorzystano informacje z 28 078 próbnych dojów pochodzących od 17 618 krów rasy HF, które wycieliły się w latach 2011–2014. Wykazano istotną zależność ($P \leq 0{,}001$) między LKS w mleku z próbnych udojów, a wybranymi wskaźnikami płodności. Stwierdzono, że skuteczność pierwszej inseminacji malała o około 6% wraz ze wzrostem LKS w mleku. Wraz ze wzrostem liczby komórek somatycznych w mleku wydłużał się okres międzywycieleniowy (o 3 dni) i okres usługi (o 6 dni) oraz wzrastała wartość indeksu inseminacji z 1,99 u krów z LKS <100 tys. $\cdot$ ml^{-1} do 2,03 u krów z LKS >1 000 tys. $\cdot$ ml^{-1}. Zależność ta została potwierdzona dodatnimi wartościami współczynników korelacji między LKS a OMW, OU i II. Hodowcy bydła mlecznego powinni zwracać uwagę na wzrost LKS w mleku, między innymi ze względu na ich niekorzystny wpływ na płodność krów.

Słowa kluczowe: krowy mleczne, liczba komórek somatycznych, płodność, rasa holsztyńsko-fryzyjska