

# Milk SCC levels impact on fertility indicators in Ayrshire cows

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**Abstract.** The paper examined the associative links affecting the fertility indicators of cows. The study was conducted in one of the highly productive herds for breeding Ayrshire cattle (milk yield level of 8000–9000 kg of milk). Based on the data of 3866 lactations, we analyzed the following reproduction indicators: indifference period, conception rate after the first insemination, early embryonic mortality, insemination period, insemination index, service period. We carried out an indirect assessment of the state of the udder in cows based on the somatic cell count (SCC) in milk. The age of the cows was considered as a factor of the SCC variability. We analyzed the relationship between the somatic cell level and reproductive indicators. We found that the milk yield and somatic cell content in milk increase in cows with age. We found a curvilinear relationship between productivity and SCC in milk. The study established that the level of somatic cells affects the reproductive indicators. Cows with a healthy udder (SCC < 100 thousand / ml), compared to conditionally healthy ones (SCC < 300 thousand / ml), became pregnant more often after the first insemination, had a lower insemination index and a level of early embryonic mortality.

## 1 Introduction

One of the common problems in high-yielding dairy herds is subfertility syndrome in cows during early lactation. Most often, this is associated with metabolic changes in the process of converting high feed energy into milk [1]. Disruption of metabolic processes during the milking period, caused by the mobilization of the body's resources against the background of a negative energy balance, leads to a decrease in the resistance of highly productive cows to unfavorable environmental factors [2]. First-calf heifers, whose growing organism requires additional energy resources, may suffer to a greater extent [3].

Weakened immunity contributes to increased susceptibility of cows during the transition period to infectious diseases such as mastitis [4]. Cows with udder inflammation in the first hundred days after calving are characterized by a longer period until the first fruitful insemination, a higher number of inseminations per fertilization, and a reduced frequency of fertilization at the first insemination [5]. Meanwhile, data from some studies do not confirm the negative impact of subclinical mastitis on the reproductive function of cows [6].

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The main diagnostic method for the latent form of mastitis, which is most common in dairy herds, is determining the somatic cell count (SCC) in milk [7]. Low but statistically significant positive correlations have been established between the somatic cell count in milk and fertility parameters. Given this circumstance, SCC can simultaneously be an indicator of the state of health of animals, as well as an additional indicator of the reproductive function of cows [8]. However, we should consider the dependence of SCC on a wide range of factors in milk of healthy cows [9]. The values of the correlation coefficients between SCC and fertility parameters can vary depending on the first insemination ( $r = 0.030-0.072$ ), as well as on the number of cows in the herd ( $\leq 20 r = 0.034$ ,  $>200 r = 0.061$ ) [10].

Thus, the data available in the literature indicate that there is no consensus among scientists in this area of scientific research. Besides, the multifactorial nature of the variability of fertility indicators requires its further comprehensive study.

The aim of our research was to study the relationship between fertility indicators and the health of the udder in cows, mediated through the number of somatic cells in milk. Particular attention was paid to first-calf heifers.

## 2 Materials and methods

The research was carried out in the conditions of a breeding farm for purebred Ayrshire cattle in the Republic of Karelia, Russia. The herd consisted of 1235 cows. The average milk yield per forage cow was over 8000 kg of milk. The cows are kept in loose housing with automated feed distribution. The quality of housing and the level of feeding on the farm are characterized as high.

The data of 3866 consecutive lactations of cows were taken into account. We used the databases (SELEKS program) and "Cow calving and insemination logs" for the research. We considered the following indices of cow reproductive capacity: the period from calving to the first insemination – the indifference period (IP), the period from the first to fruitful insemination – the period of insemination (PI), the period from calving to fruitful insemination – the service period (SP), number of inseminations per conception – conception index (CI), fertility after the first insemination – conception rate (CR), early embryonic mortality (EEM).

Early embryonic mortality in cows was recorded based on the extended intervals (25–35 days) between consecutive inseminations. The EEM level was determined as the percentage of the number of extended intervals to the total number of cows examined.

The study included cows that did not have any reproductive system pathology during the study period.

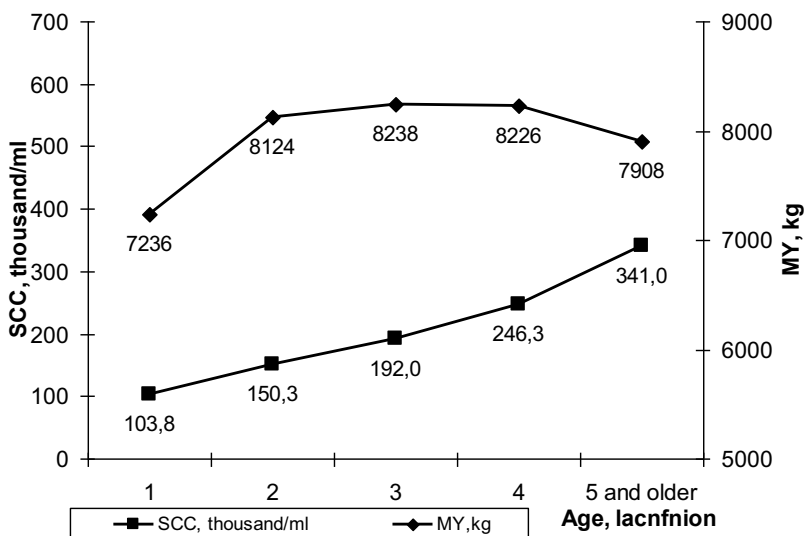
Indirect assessment of the mammary gland condition in cows was performed based on the somatic cell count (SCC) before and after the first insemination. All the studied livestock was divided into groups: healthy –  $SCC < 100$  thousand/ml; conditionally healthy –  $SCC < 300$  thousand/ml; animals with subclinical mastitis –  $SCC < 500$  thousand/ml;  $SCC < 700$  thousand/ml;  $SCC \geq 700$  thousand/ml. The somatic cell count was determined in 19,463 milk samples collected during monthly control milkings of the cows. The milk was analyzed in a specialized laboratory using Bentley Combi FTS-500 equipment using infrared spectrometry.

The age of the cows was considered as a factor of the variability of the SCC in milk.

The milk yield for 305 days of lactation (MY) and the average daily milk yield (DMY) were also taken into account.

## 3 Results

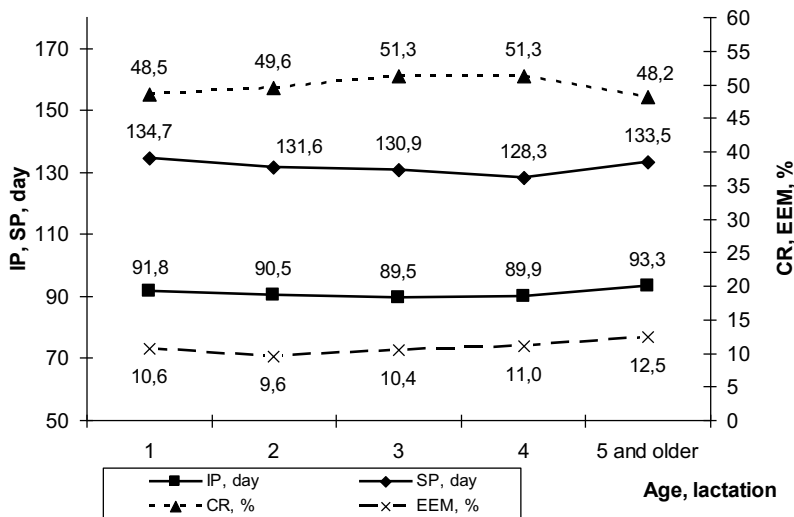
The general analysis of the herd showed that the age factor affects the SCC indicator in milk and the milk yield of cows (Figure 1). First-calf heifers had a healthy udder relative to the average SCC value established for them. In cows of the 2nd–4th lactation, the increase in somatic cells in milk corresponded to the status of conditionally healthy. The SCC level in the oldest animals indicated the presence of a latent form of mastitis ( $P<0.001$ ). The analysis of changes in milk yield in cows of different age indicates the presence of a curvilinear relationship between productivity and the number of somatic cells in their milk. First-calf heifers yielded 1002–672 kg of milk less than older cows ( $P<0.001$ ).



**Fig. 1.** Effect of age on the milk SCC and milk yield in Ayrshire cows.

However, when the SCC reached the level corresponding to latent inflammation of the mammary gland, the oldest cows showed a decrease in milk yield (318 kg) compared to the conditionally healthy group of cows ( $P<0.01$ ). This nature of the change in the relationship indicates that the somatic cell level associated with age also had an indirect effect on the change in milk yield in cows.

Our study did not reveal the influence of age and the associated change in SCC in milk on the reproductive function indices. Only the oldest cows (SCC=341 thousand/ml) showed a tendency towards an increase in cases of early embryo mortality (Figure 2).



**Fig. 2.** Reproductive function indicators in cows, taking into account age.

A study of the indirect relationship between fertility indices and the inflammatory process in the mammary gland (Table 1) established that the longest period from calving to the first insemination and fertilization was observed in individuals with a severe form of mastitis ( $SCC \geq 700$  thousand/ml). They restored cyclicity after calving 7–8 days later than cows with a healthy and conditionally healthy udder ( $P < 0.05$ ).

**Table 1.** Fertility indicators of cows depending on the SCC (on average per lactation).

Indicators	Gradations by SCC, thousand/ml				
	less than 100	100-299	300-499	500-699	700 and more
Herd average					
Heads	2498	876	207	100	185
SCC, thousands/ml	41.1+0.5	198.5+1.9	386.6+4.1	592.8+5.6	1463+87
MY, kg	7908+26	7701+45	7751+92	7732+125	7630+100
IP, days	90.9+0.9	89.9+1.4	91.4+2.6	87.2+4.3	97.5+3.3
PI, days	41.2+1.2	44.1+2.0	34.9+3.8	35.6+5.3	41.9+4.5
SP, days	132.1+1.4	134.0+2.3	126.3+4.1	122.9+7.3	139.3+4.9
CI	1.86+0.02	1.95+0.04	1.79+0.08	1.79+0.11	1.91+0.1
CR, %	50.3	45.4	54.1	51.0	54.1
EEM, %	9.6	13.1	9.7	11.0	10.3

Note. MY - milk yield for the first 305 days of lactation, SCC – somatic cells count, IP – the indifference period, PI – the period of insemination, SP – the service period, CI - conception index, CR – conception rate (fertility after the first insemination), EEM - early embryonic mortality.

It should be noted that the highest milk yield was demonstrated by cows with a healthy udder ( $SCC < 100$  thousand/ml). Compared with them, cows with a relatively healthy udder ( $SCC = 100-299$  thousand/ml) had a lower milk yield by 207 kg ( $P < 0.001$ ), cows with severe inflammation of the mammary gland by 278 kg of milk ( $P < 0.01$ ). At the same time, a greater number of healthy individuals required fewer inseminations for conception ( $P < 0.05$ ), and they had less frequent EEM recordings ( $P < 0.01$ ) compared with relatively

healthy cows. This indicates that inflammatory processes in the udder can simultaneously have a negative effect on the amount of milk yield and the reproductive capacity of cows.

Indirect assessment of the mammary gland condition in the herd showed that over 87% of cows had healthy and relatively healthy udders, including 95% of the examined first-calf heifers. The quality of first-calf heifers and their adaptive capabilities in intensive production conditions are important for the efficiency of the dairy herd. The most indicative period from this point of view is early lactation - the first three months after calving.

The study did not reveal any significant deterioration in most reproductive function indices in first-calf heifers with latent mastitis diagnosed before the first insemination compared to healthy cows. We noted a tendency toward an increase in the period before the first fruitful insemination when the somatic cell count in milk was over 300,000/ml (Table 2).

**Table 2.** Fertility rates of cows in the first lactation depending on the SCC in the period from calving to the first insemination.

Indicators	Total	including gradations by SCC, thousand/ml			
		less than 100	100-299	300-499	500 and more
Heads	920	810	71	15	24
SCC, thousand/ml	71.9±6.1	30.4±0.7	125.3±6.9	407.1±14.9	977.0±120.0
DMY, kg/day	28.5±0.1	28.6±0.2	27.3±0.5	29.8±0.8	27.6±0.8
IP, days	92.5±1.4	91.8±1.5	95.9±5.3	113.4±18.6	97.6±11.2
PI, days	42.5±2.0	42.3±2.1	43.2±6.5	53.0±21.9	51.5±10.4
SP, days	134.9±2.3	134.1±2.4	139.2±8.3	166.4±28.7	149.1±15.7
CI	1.91±0.04	1.90±0.04	2.00±0.16	1.65±0.21	2.08±0.17
CR, %	48.0	48.0	52.1	60.0	29.2
EEM, %	11.2	11.1	9.9	0.0	25.0

Note. SCC – somatic cells count, DMY – daily milk yield IP – the indifference period, PI – the period of insemination, SP – the service period, CI - conception index, CR – conception rate (fertility after the first insemination), EEM - early embryonic mortality.

Cows with SCC of 500 thousand/ml and more had a significantly lower number of first successful inseminations after calving, and they also had a significantly higher rate ( $P<0.05$ ) of early embryo mortality compared to healthy, conditionally healthy cows, and cows with subclinical mastitis, but with SCC in 1 ml of milk of less than 500 thousand ( $P<0.05$ ).

The condition of the mammary gland did not affect the amount of milk yield of young cows. The differences in this feature between the groups of healthy cows and cows with mastitis were within the limits of a statistical error.

The comparative analysis showed that the reproductive function of first-calf heifers suffers to a greater extent from severe inflammation of the mammary gland at the beginning of lactation (SCC=977 thousand/ml) than that of mature cows. Young cows became pregnant significantly less often from the first insemination after calving, and their EEM level was more than 2 times higher ( $P<0.05$ ).

## 4 Discussion

An increase in somatic cells in milk was associated with a decrease in milk yield of cows. This is supported by a high correlation coefficient ( $r=0.832$ ) between SCC and a decrease

in milk productivity due to mastitis, established in other studies [11]. The maximum duration of the period from calving to first insemination (IP) and the onset of pregnancy in cows with the highest SCC indicate that mastitis is directly related to a delay in the onset of ovarian activity after parturition, and the type of mastitis may indicate the degree of its negative impact on reproductive function [12]. It has been established that the effect of anti-inflammatory cytokines, which are produced in response to udder infections, causes a disorder of follicle formation, a decrease in embryo quality and pregnancy loss [13].

First-calf heifers are less likely to suffer from inflammatory processes of the udder. This may indicate their higher immunity of the mammary gland [14]. The greatest negative effect of mastitis in relation to such indicators as CR and EEM was noted in first-calf heifers only with a high SCC ( $\geq 500$  thousand/ml) compared to older cows.

Our established correlation between high SCC levels in pre-insemination milk samples and low conception rates and frequent cases of early embryo mortality, which has also been noted in other studies [15], may be related to the effect of a suboptimal follicular environment on oocyte and embryo quality [16].

## 5 Conclusion

The results of this work showed that there is a quantitative relationship between mastitis incidence, milk yield and reproductive function indices in dairy cattle. Thus, to ensure high productivity and reproductive efficiency of dairy cows, mastitis prevention is of great importance. Given the age-related features of the manifestation of the influence of mastitis on reproductive indices revealed in the work, as well as the complexity and dependence of the reproductive system on many other factors, further research is needed.

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