Bulgarian Journal of Agricultural Science, 24 (Supplement 1) 2018, 72-81

SOMATIC CELL COUNT IN MILK AND ITS RELATION WITH CLINICAL MASTITIS AND LINEAR TYPE TRAITS IN BLACK-AND-WHITE COWS

IVAYLO MARINOV
Department of Animal Science – Ruminants and Dairy Farming, Faculty of Agriculture, Trakia University, 6014 Stara Zagora, Bulgaria

Abstract

MARINOV, I., 2018. Somatic cell count in milk and its relation with clinical mastitis and linear type traits in black-and-white cows. *Bulg. J. Agric. Sci.*, 24 (Suppl. 1): 72–81

The aim of the study was to establish the relationship between some environmental and parathypical factors and udder type traits and the somatic cells count and the cases of clinical mastitis in Black-and-white cows. In the study 317 Black-and-white cows from 9 dairy farms were included. Farms were from different regions of the country and with different housing system, respectively 3 with tied housing, 1 with a loose housing and 5 with free stall housing system. Cows included in the study were from first to third lactation, respectively 129 on first, 121 on second and 67 on third lactation. The average milk yield for 305-day lactation of the cows included in the study was 7438.6 kg. The average somatic cell count was 237 880 cells/ml, and the average percentage of clinical mastitis incidence was 14.03% with variation for the different farms from 6.0% to 26.3%. A statistically significant effect of the farm ($p<0.001$) and parity ($p<0.01$) on SCC in milk was found, and on clinical mastitis significant effect only of the farm ($p<0.01$) was reported. The level of milk yield had no significant effect on both traits. A significant phenotypic correlation between somatic cell count and rear udder height (-0.25), central ligament (-0.23), udder depth (-0.11), rear teat position (0.11), and teat length (0.13) was found. The phenotypic correlation between somatic cell count and clinical mastitis was 0.14. A significant correlation between clinical mastitis and udder conformation traits was not reported.

Key words: dairy cows, somatic cells count, clinical mastitis, udder conformation traits, milk yield

Abbreviations: SCC - somatic cells count; CM – clinical mastitis

Introduction

Mastitis are the most expensive disease in dairy cattle because of their negative effect on the herd's milk yield, the animals welfare and economic implications for farms, including losses in milk production, increased culling rates and veterinary services costs (Winkelman et al., 2003; Bouška et al., 2006; Němcova et al., 2007; Dürr et al., 2008; Rekik et al., 2008). Regardless of their importance, control and data collection for them is difficult and in very few countries the cases of mastitis are controlled (Heringstad et al. 2000).

As a result of mastitis, increased somatic cell count (SCC) in milk is reported, which can be used as an indicator for the assessment of udder health (Fregonesi and Leaver, 2001). A positive correlation between cases of mastitis and SCC in milk was found, moreover, in most populations, the heritability for SCC is relatively higher - in a range of 0.15 to 0.25 for different definitions of SCC (Muir et al., 2007; Samoré et al., 2008; Bohmanova et al., 2009; Miglior et al., 2009), compared to that of mastitis - 0.02 to 0.05 (Rupp and Boichard, 1999; Ǿdegard et al., 2004; Bloemhof et al., 2009), which means that SCC can be an indirect selection criteria to improve cows' genetic resistance to mastitis. The selection for resistance to mastitis based on indirect selection for SCC in milk has been extensively studied and applied in many countries (Windig et al., 2010; Interbull, 2011).

The results of numerous studies indicate the existence of a significant genetic relation between the number of somatic

e-mail: marinov.ib@abv.bg

cells and some linear type traits, especially those of the udder (Misztal et al, 1992; Rupp and Boichard, 1999; DeGroot et al., 2002). The use of conformation udder traits as indicator is widely used as a means of improving the accuracy of selection for resistance to mastitis (DeJong and Lansbergen, 1996; Gengler and Groen, 1997; Mrode et al., 1998). There is a great potential for improving udder health by selection for linear type traits of udder, and also for SCC, especially taking into account that higher SCS (logarithmic transformation of the SCC) is genetically associated with a higher incidence of CM (Nash et al., 2000, 2002).

The aim of the present study was to establish the relation between some environmental and parathypical factors and udder type traits and the somatic cells count and the cases of clinical mastitis in Black-and-white cows.

Material and methods

The study included 317 cows from 9 dairy cattle farms. Farms were from different regions of the country and with different housing system respectively 3 were with tied housing, 1 with loose housing and 5 with free stall housing system. Farms are presented with serial numbers because of the confidentiality desired by the farmers.

For all the cows included in the study, data from the official control of productivity for the traits included in the study were taken – milk yield, percentage of fat, percentage of protein and somatic cell count (SCC) in milk for 305-day lactation. Only data for animals with 8 to 10 test day controls available were used, and respectively lactations from 240 to 305 days. To study the effect of milk yield on SCC, milk yield was presented in the following classes - up to 4000 kg; from 4001 to 6000 kg; from 6001 to 8000 kg; from 8001 to 10000 kg and above 10001 kg.

From the diaries of the veterinary specialists on the farms, the data on registered cases of CM during the current lactation for cows included in the study were taken. For statistical analysis purposes, codes were used: code 1 - no reported CM and code 2 - reported at least one case during the current lactation.

On all cows a linear scoring of the udder's conformation traits was made, using a scale from 1 to 9, according to the instructions of ICAR (2014) and WFFH (2012). According to the regulation for implementing the scoring system, part of the linear type traits were measured and on the basis of the established dimensions were distributed in the scale from 1 to 9, according to the relevant for each trait reference scale. Cows were scored from the 30th to the 210th day of lactation. Cows included in the study were randomly chosen - all animals in the technological groups in the beginning and middle of lactation, respectively 129 on first, 121 on second and 67 on third lactation. The beginning of the scoring was not earlier than 2 hours after morning milking.

For the data processing, the relevant modules of the Statistica package were used.

To evaluate the effect of controlled factors on SCC and CM, the following model was used:

$$Y_{ijkl} = \mu + H_i + L_j + M_k + e_{ijkl}$$

Where:

$\mathbf{Y_{ijkl}}$ was a studied trait (SCC and CM); $\mathbf{H_i}$ was the fixed effect of the farm; $\mathbf{L_j}$ was the fixed effect of parity; $\mathbf{M_k}$ was the fixed effect of the level of milk yield and $\mathbf{e_{ijkl}}$ was the effect of uncontrolled factors, the error.

By analysis of variance (ANOVA) for the model the least squares means (LSM) were obtained by classes of fixed factors.

Results and discussion

The average milk yield for 305-day lactation of cows included in the study was 7438.6 kg, with considerable individual variation (Table 1). Lowest average milk yield had the cows of herd 8 - 3744.8 kg, and the highest - herd 5 with 9791.4 kg. The average fat and protein percentage in milk for 305-day lactation were with optimal for the breed values, respectively 3.78 and 3.39%, as the variation in fat percentage was slightly higher.

The average milk yield of the cows included in the study was much higher than the average for the controlled in Bulgaria Black-and-white cows. According to the EASRAB data for 2013, the average milking yield for controlled cows of this breed was 5300-5600 kg, with the protein percentage being 3,20-3,30% and the fat percentage - 3,60-3,80% (Nikolov et al., 2013).

The average SCC was relatively low – 237 880 cells/ml, but the variation in this trait was considerable. The average percentage of CM incidence in the cows included in this study was 14.03% with variation between farms from 6.0% to 26.3%.

Bytyqi et al. (2010) found that the milk of cows of high-yielding breeds such as Brown-Swiss (423 310 cells/ml) and Black Holstein (310 360 cells/ml) had a higher SCC. Similar results were pointed of Heringstad et al. (2000).

Kelly et al. (2009) surveyed 398 randomly selected Irish dairy farms where cows were mainly housed on pasture. The average SCC for the farms was 282 887 cells/ml, ranging from 82 209 to 773 028 cells/ml. Norman et al. (2017) showed for 2016 average SCC at national level in USA 203 000 cells/ml.

Heringstad et al. (2000) reported that the incidence of CM per year ranges from 20 to 40%. Santman-Berends et al.

(2015) in a survey of 240 Dutch dairy farms found an average of 32.5% of cases of CM. According to AHDB (2017), the incidence of CM in UK dairy herds for the past 10 years is about 30 per 100 cows.

From the analysis of variance for the influence of controlled factors on SCC a statistically significant effect of the farm (P <0.001) and the parity (P <0.01) was found, Table2. The level of milk yield had no significant effect on SCC.

On CM, a significant effect was found only of the farm (P <0.01).

On Fig. 1 the percentage of cows with CM and LS-mean of SCC in milk by farms are presented. In the cows included in the survey, a high percentage of CM in three of the farms was reported, ranging from 19.3 to 26.6%. No relation with housing system was found, although in these three farms with a high percentage of CM the cows were loose housed and free stall housed and milked in milking parlor. In the other farms, the percentage of cows with CM for the current lactation was below 10%, from 6.0 to 8.9%, respectively.

Only at one of the farms (farm 9) the average SCC in the milk of the cows included in the survey was above the sale limit - 400 000 cells per ml. The average SCC in milk in cows from 5 farms was within the allowable for healthy udder - up to 200 000 cells/ml.

A relationship between farms with a high percentage of CM and high SCC was not reported. Only for farm 9, which was with the highest SCC – 573 770 cells/ml, a higher percentage of cows with CM - 19.4% was reported. In the other two farms with the highest percentage of CM (25.0 and 26.3%) LS-means for SCC was within the normal range of 201300 and 162900 cells/ml. It is obvious that in cows in farms 4, 7 and 8 a high SCC was reported - over 300 000 cells/ml, but a low rate of CM, less than 10%. Possible reasons for these inconsistencies can be sought in two respects - failure to comply with good hygiene practices related to milking and rearing conditions of the cows on these farms, leading to more serious deviation in SCC and the incidence of CM, without this being related to housing system and the type of milking equipment, and the possible presence of subclinical mastitis, not reported by veterinarians at the farms. In cases of subclinical infection of the udder, pathogenic microorganisms do not cause alveolar tissue disruption, to the extent that this can be seen in milk, but the infection can be detected by the increased number of somatic cells per ml of milk (Caraviello, 2004). This could be one of the reasons for the inconsistencies.

A number of studies have also shown that farms where all hygiene practices in cow housing and milking are com-

Table 1
Mean values and standard deviations for the main productive traits

Trait	x ± SE	SD	min	max
Average 305-day milk yield, kg	7438.6 ± 138.81	2436.1	2071.54	15675.1
Average fat percentage	3.78 ± 0.03	0.427	2.70	4.90
Average protein percentage	3.39 ± 0.01	0.178	2.40	4.19
Average SCC, thousand/ml	237.88 ± 14.09	250.87	0.00	2142.11
Average percentage of CM incidence	14.03	-	6.0	26.3

Table 2
Analysis of variance for influence of the controlled factors on SCC and CM

Source of variation	Degrees of freedom (n-1)	SCC. thousand/ml		CM	
		MS	F P	MS	F P
Total for the model	14	480799	10.74 ***	0.192	1.88 *
Farm	8	718255	16.04 ****	0.227	2.17 **
Parity	2	151517	3.38 **	0.098	0.94 -
305-day milk yield	4	51704	1.15 -	0.072	0.60 -
Error	302	44782		0.105	

* - significance at P <0.05; ** - significance at P <0.01; *** - significance at P <0.001; - no significant effect

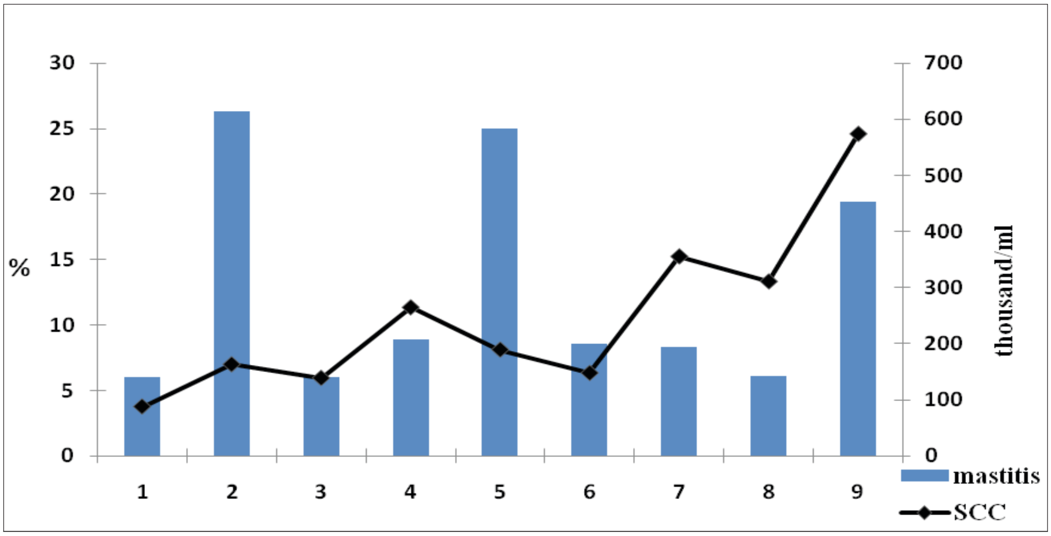

Fig. 1. Percentage of CM incidence and SCC by farms

piled have a considerably lower number of somatic cells in milk (Barkema et al., 1998, Hutton et al., 1990). Kelly et al. (2009) establish a significant relation between low SCC and increased hygiene levels and the cleanliness of walking yards, alleys and stalls.

Fig. 2 presents the percentage of CM and the LS mean for SCC in the milk for 305 day lactation for the cows included in the study by parity.

In multiparous, a higher SCC in milk for 305 day lactation was reported. With the lowest LS-mean SCC in milk were the cows on first parity – 218 700 cells/ml, and the highest ones were those on third parity – 332 400 cells/ml. A similar trend was also seen in the percentage of CM, although no significant effect of the number of parity was reported. With the highest percentage of CM were the cows on third parity - 15.8%. In cows on first and second parity there was no difference, the rate of CM incidence was respectively 11.5 and 11.6%.

Other authors have found a similar trend of increasing incidence of mastitis with the rise of the number of parity (Radostits et al., 2000). Rahman et al. (2009) found a tendency to increase the percentage of diseased from mastitis cows after a second parity. A number of authors reported such a trend and in SCC. This increase was mainly due to the increasing prevalence of infections in older cows, but not because of the age itself. Bytyqi et al. (2010) found that primiparous and those on sixth and over parities, appear to be less exposed to a udder infection, and respectively SCC

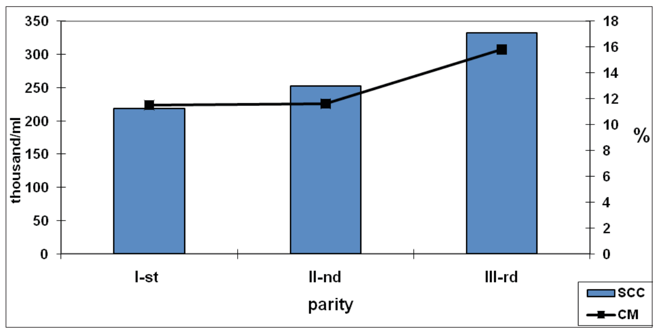

Fig. 2. Percenage of CM and SCC depending on the number of parity

in milk was about 178 450 cells/ml and 205 610 cells/ml. The highest SCC had the cows on third parity (338 430 cells/ml), followed by those on second (322 610 cells/ml) and fourth (308 660 cells/ml).

On Table 3 are shown the mean values and the variation for the udder linear type traits of the cows included in the study. Below the average was the udder depth at 3.78, indicating a certain trend for udder's floor closer to the hocks. Slightly below the average (desired) value was the score for the udder balance - 4.55 and teats length - 4.76. A greater deviation for teat thickness - 4.40 was observed. This shows a tendency to low-hanging rear udder, and shorter and thinner teats. The average score for fore udder attachment was

5.38, this shows a tendency to intermediate attachment or cup shaped udder. For this treat desirable are higher values associated with better development of the fore udder forward to the abdomen and more tight attachment to the abdominal wall. Also a trend for closer placement of the rear teats was observed (6.48).

Pantelić et al. (2010) indicate, that at Holstein in Serbia the LS-means values for udder traits ranged from 4.91 (teat length) to 6.92 (rear udder width). The udder balance had an average value of 5.05, and the central ligament - 6.35. Duru et al. (2012) found for the first three lactations in Holstein cows in Turkey average values for udder traits similar to ours: for the fore udder - 6.05, for the rear udder height - 6.15, and for the central ligament - 5.40. Better values had the udder depth (5.48), rear teat placement (5.17) and teat length (5.55). Zavadilová et al. (2011) found in Czech Holstein primiparous linear scores for udder traits predominantly about the average values: fore udder attachment - 5.19, rear udder height - 5.50, rear udder width - 5.32, central ligament - 5.63, udder depth - 5.77, front teat placement - 4.93, rear teat placement - 5.59 and teat length - 4.71.

On Table 4 the phenotypic correlation between udder linear type traits and SCC and CM are presented.

Significant phenotypic correlations between SCC and five of the udder liner traits were found. Significant and with negative values were the correlations between SCC and rear udder height (-0.25), central ligament (-0.23) and udder depth (-0.11), whereas between rear teat placement (0.11) and teat length (0.13) they were positive, although with low values.

Phenotypic correlations between SCC in milk and milk yield and average fat percentage for 305-day lactation were significant and negative, respectively (-0.12) and (-0.20). High SCC in milk was related with lower milk yield and low fat percentage. The correlation between protein percentage and SCC was about 0 and was not significant. Negative phenotypic correlation between SCC and milk yield (-0.14) was found for Finnish Ayrshire, (Koivula et al., 2005).

SCC in milk had a significant positive phenotypic correlation with the cases of CM (0.14). Between the reported cases of CM and the udder type traits a significant phenotypic correlation was not reported, all values were close to 0. The lack of significant phenotypic correlations could be due to the relatively small number of animals included in the study. On the other hand this may be due to the previously mentioned possible presence of subclinical mastitis, not reported by vets in a large number of farms, especially in farms with higher SCC.

The direct selection for mastitis resistance is not widely practiced due to low heredity (Amin et al., 2002; Zwald et al., 2004; Koivula et al., 2005) and to the fact that cases of mastitis are difficult to control. According to Ptak et al. (2009), mastitis are one of the most common diseases in dairy cows, but in many countries, including Poland, diseases of mastitis are not registered and therefore direct selection is not possible. Only Denmark, Norway, Finland and Sweden, have well-developed and implemented system for Disease Control in dairy farming and therefore only they include direct CM in breeding programs (Heringstad et al., 2000).

Table 3
Mean values and standard deviations for the linear type traits of udder

Linear type trait	Statistical indicators			
	x ± SE	SD	1	9
Fore udder attachment	5.38 ± 0.09	1.62	Loose	Strog
Rear udder height	6.66 ± 0.09	1.66	Low	High
Rear udder width	6.18 ± 0.09	1.68	Narrow	Wide
Central ligament	5.79 ± 0.08	1.43	Broken	Strong
Udder depth	3.78 ± 0.10	1.77	Deep	Shallow
Udder balance	4.55 ± 0.05	0.93	Deep rear	Deep front
Front teat placement	5.12 ± 0.06	1.13	Wide	Close
Rear teat placement	6.49 ± 0.10	1.76	Wide	Close
Teat length	4.76 ± 0.06	1.10	Short	Long
Teat thickness	4.40 ± 0.04	0.74	Thin	Thick

Table 4
Phenotypic correlation between linear type traits and SCS and CM

Linear type trait	SCC thousand/ml	CM
Fore udder attchment	0.09	-0.02
Rear udder height	**-0.25**	0.07
Rear udder width	0.03	-0.06
Central ligament	**-0.23**	-0.04
Udder depth	**-0.11**	-0.03
Udder balance	-0.07	-0.03
Front teat position	0.06	0.01
Rear teat position	**0.11**	-0.01
Teat length	**0.13**	-0.01
Teat thickness	0.11	0.02
305-day milk yield	**-0.12**	-0.06
Milk fat, %	**-0.20**	-0.06
Milk protein, %	-0.08	0.08
Rate of CM	**0.14**	-

Phenotypic correlations marked with bold are statistically significant at P <0.05

On Figures 3 to 7 are shown the average values for SCC depending on the values of the linear traits that had significant correlations with the SCC.

For the rear udder height clear dependence was observed that in udders with low attached rear part a high SCC was reported. Under score 3 and less, which corresponds to a distance to the lower end of the vulva greater than 35 cm, the SCC was over 400 000 cells/ml. In udders with high attached rear part, score over 6 (less than 27cm) the SCC was below 200 000 cells/ml. Lower attachment of the rear udder is a precondition for low-hanging rear quarters (tilted floor) and the udder as a whole.

In the trait central ligament a trend for higher SCC in udders with less pronounced ligament was reported, score 4 and less. This corresponds to weak cleft, shallower than 2 cm, and lack of cleft or flat udder floor.

In udders with floor below the hocks (score 1) the highest SCC was reported. Unfortunately, these are usually highly productive large udders with an advantage in capacity.

Dube et al. (2009) believe that the deeper udders are more susceptible to injuries and pollution, due to their position relative to the ground. Detilleux and Leroy (1999) found that wide and deep udders were more common in cows with the highest milk yield breeding values than in cows with lower breeding values.

In rear teat placement, the lowest SCC was reported for udders with intermediate teat placement – optimal distance and vertically directed downward (scores from 4 to 6). Higher SCC (over 300 000 cells/ml) was reported at closely located and inwardly directed rear teats (scores 8 and 9).

Dube et al. (2009) point, that closely located rear teats are associated with low SCC, probably due to the easier operation during machine milking.

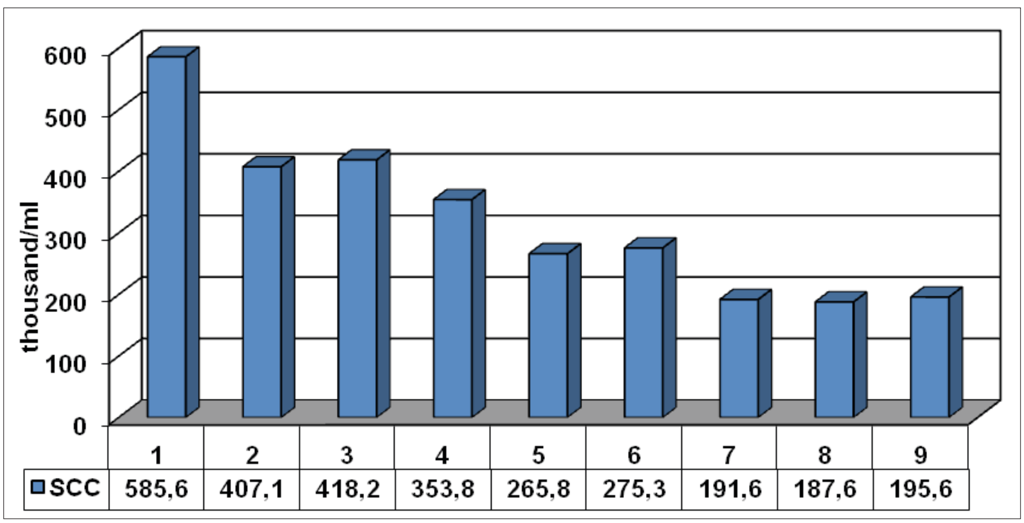

Fig. 3. Average values for SCC depending on the rear udder height

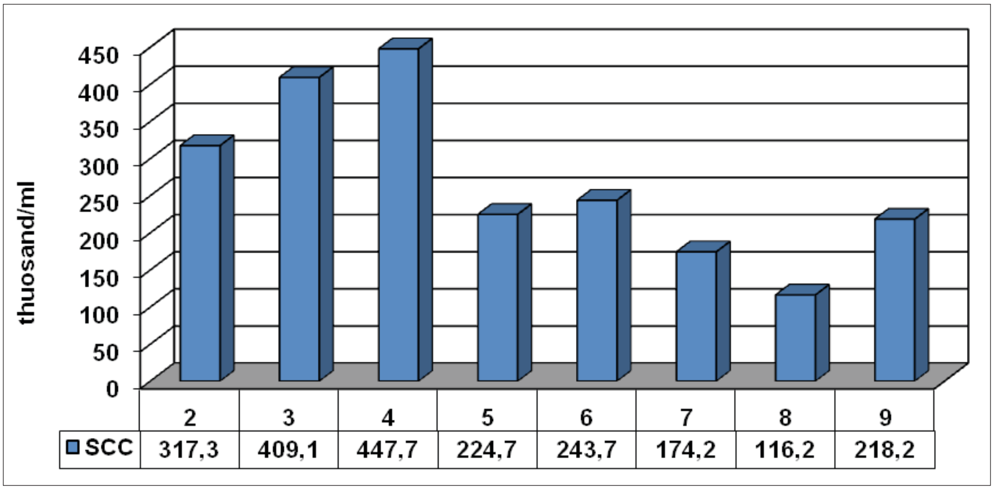

Fig. 4. Average values for SCS depending on the udder central ligament

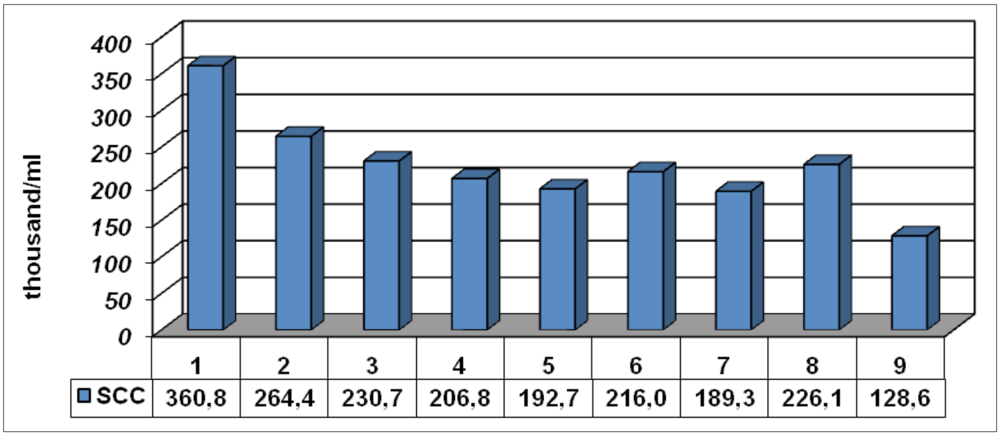

Fig. 5. Average values for SCC depending on the udder depth

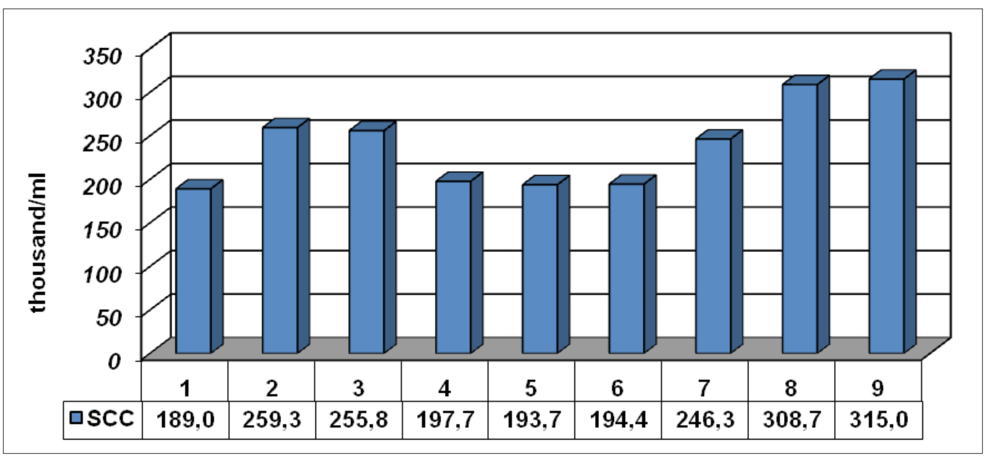

Fig. 6. Average values for SCC depending on the rear teat position

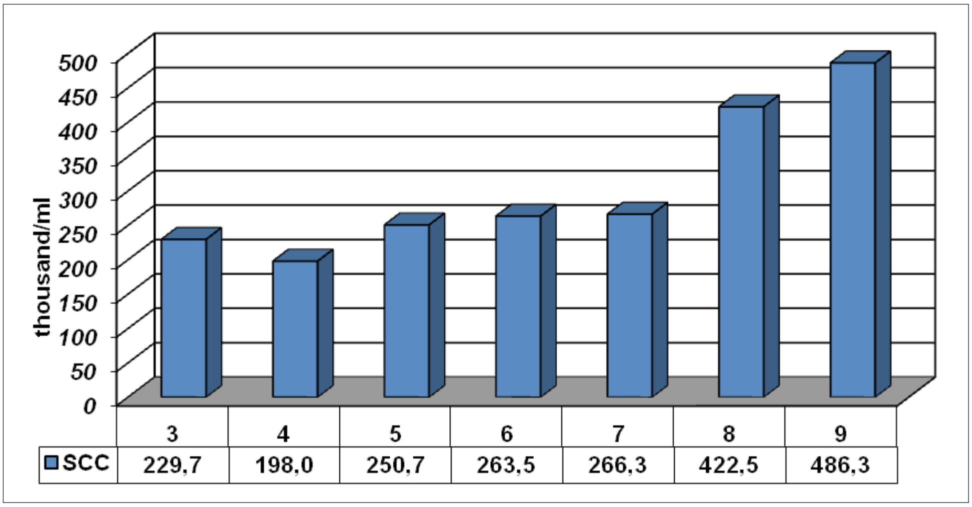

Fig. 7. Average values for SCC depending on the teat length

For the teat length, a clear tendency was observed for teats over 8 cm in length, the reported SCC to be above 400 000 cells/ml. In this trait, teats with length less than 2 cm were not measured.

Berry et al. (2004) found positive genetic correlation between the SCC and the length of the teats (0.31) in Holstein primiparous. The authors believe that increasing the SCC in cows with longer teats may be due to the fact that the longer teats are exposed to a greater risk of injuries during rearing, servicing and milking. Similar conclusion was made by Dube et al. (2009). Rogers and Spencer (1991) showed a trend (albeit without statistical significance) for increased "crawling" of milking cups in long and thick teats during milking, which was a precondition for milking problems and occurrence of new udder infections, and also was related with more labor costs.

The results obtained show that in udders with higher attached rear half (distance between the bottom of the vulva and the milk secreting tissue less than 27cm), stronger central ligament (cleft deeper than 2 cm), udder floor placed above the hocks, rear teats with optimal placement, directed perpendicularly and not longer than 8cm a lower SCC was reported, which correspond to healthy udder.

In general, favorable (negative) genetic correlations were found between some linear udder traits and SCC (Rupp and Boichard, 1999; Kadarmideen, 2004), and in particular the udder depth and the fore udder attachment. The genetic correlations indicate that cows with higher, more tightly attached udder and more closely spaced teats have a lower SCC. Nemcova et al. (2007) concluded that the score of certain linear udder traits (fore udder attachment, udder depth, central ligament, rear udder height, front teat placement, teat length) can be used as a positive criterion for selection of cows with low SCC and good milk yield. Cows with higher attached rear udder, centrally located teats with medium length were preferably. The optimal values of the linear udder traits were not associated with a lower milk yield.

Conclusions

The average milk yield for 305-day lactation of the cows included in the study was 7438.6 kg. The average SCC was 237 880 cells/ml, and the average percentage of CM incidence was 14.03% with variation for the different farms from 6.0% to 26.3%. A statistically significant effect of the farm (P <0.001) and the parity (P <0.01) on SCC in milk, and on the CM incidence only of the farm (P <0.01) was reported. The level of milk yield had no statistically significant effect on both traits. In udders with higher attached rear half (distance between the bottom of the vulva and the milk secreting tissue less than 27cm), stronger central ligament (cleft deeper than 2cm), udder floor placed above the hocks, rear teats with optimal placement, directed perpendicularly and not longer than 8cm a lower SCC was reported, which correspond to a healthy udder.

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