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Research Article

Relationship Between Somatic Cell Count and Milk Production or Morphological Traits of Udder in Black-and-White Cows

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Abstract: The objective of this study is to relationship between the somatic cell count (SCC), milk production and the morphologic traits of udder in the herds of Black-and-White cattle. The data included the test day records of milk and SCC, type evaluation of 2012 Black-and-White cows of the first lactation in 143 Lithuanian herds. The findings of the study are consistent with the results of similar previous studies concerning a negative relationship between SCC and milk yield during lactation. According to the results of the study, the increase in SCC from 100,000 to 800,000 cells/ml and above decreased the milk yield of Black-and-White cows to 658 kg (14.4%), fat content - to 28.9 kg (14.7%), and milk protein content - to 13.3 kg (9.1%).

The udder and teat morphology significantly ($P < 0.001$) affected log2 SCC, hence the cows selection based on the udder morphology can serve to improve the milk quality reducing SCC in milk.

The findings of this study are consistent with the data concerning the negative relationship between SCC and milk yield during lactation and the relationship between somatic cell count and udder, or teat morphology. Reducing milk SCC the selection of Black-and-White cows based on the udder and teat morphology can improve milk quality.

Key Words: Somatic cell count, Black-and-White cattle, morphological traits of udder, milk production

Introduction

Mastitis is an infection of the mammary gland, a disease of great economic importance resulting in significant economic losses in the dairy industry. Mastitis includes clinical and subclinical infection. The economic costs of mastitis include reduced milk production, discarded milk, increased culling, increased costs of health care and labour, and reduced milk quality. In addition, mastitis contributes to consumer concerns regarding animal welfare. Strategies to control mastitis include preventive health care, hygiene, veterinary remedies, and genetic selection (1-4).

In many countries information concerning clinical mastitis is not collected by veterinarians or breeding databases. The delivery control of milk with high somatic cell counts (SCCs) has been established by EU directive (92/46) for dairy cattle. Collection of SCCs in test-day samples was started a few years ago in the countries of Central and East Europe, and a number of SCC records collected in the national database since then. Information concerning conformation linear data has been also recorded. For dairy cattle SCC in milk has been identified as an accurate indirect method to predict udder infection (mastitis) and as an indicator of milk quality. To ensure a supply of high quality dairy products, somatic cell count is monitored in milk shipments (2,5,6).

Yalçin et al. (7) and a number of other authors (8-11) have evaluated a negative relationship between SCC and milk yield.

Type classification is an important tool in the management of a profitable dairy herd. A relationship between morphological traits and udder with SCC was reported by Uzmay et al. (12) and other authors (13-16).

The aim of this study was to evaluate the relationships between milk SCC and milk production or morphological traits of udder in Black-and-White cows.

Materials and Methods

The research was carried out at the Lithuanian Black-and-White cattle improvement association, at the State Laboratory for Milk Control "Pieno tyrimai", at the Centre of State Business Development and Information, and at the Laboratory of Establishment of Animal Breeding Value and Biometry of Lithuanian Veterinary Academy.

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In Lithuania the methodology of a linear-type evaluation for cows conforms to the ICAR (International Committee for Animal Recording) standards and EU directives (77/504, 86/130, 87/328, 94/515). The following traits of cows are evaluated: height, stoutness, body depth, chest width, dairy type, rump width, rump angle, rear leg set angle, rear leg form, heel joint, hoof height, and hoof tarsus angle. The national schemes for appraisal of Lithuanian Black-and-White cattle include 7 traits of udder: fore udder attachment (FUA), rear height (RH), cleft (UC), depth (UD), teat placement (TP), length (TL) and thickness (TT). Linear assessment of each trait is scored between the biological extremes on the scale of 1 to 9. The classification evaluates the animal by means of comparison to the ideal. The optimal udder estimations of the Lithuanian Black-and-White cows must be 9 points for all traits of the udder but estimations for teat thickness, placement and length must be 5 or 6 points.

In Lithuania SCC is collected on a monthly basis dating from 1996. The data of the milk recording on the test day and SCC of all cows from 1996 were used for the investigations.

The data of cows' udder evaluation from national database were also used. Total data of 2012 first lactation cows from 143 herds were included in the records.

Using the data operating system LINUX PostgreSQL a database for data manipulation and analysis was created on the basis of cows' performance recording data received from the Centre of State Business Development and Information ORACLE database at the Laboratory of the Establishment of Animal Breeding Value and Biometry of the Lithuanian Veterinary Academy. Statistical analyses were carried out using the "R 1.8.1" package (17).

For the analysis of the relationship between SCC and the milk yield, fat and protein production of Black-and-White cows of the first lactation, the average of SCC test-day data of the whole lactation was used.

The impact of the udder and teat morphology on the SCC was determined. The test–day data of SCC was log transformed to base 2. This logarithmic transformation achieved normality of distribution. The model included the fixed effect of FUA, RH, UC, UD, TP, TL and TT in points:

$$SCC \log 2 = FUA + RH + UC + UD + TP + TL + TT$$

Results

A high number of somatic cells reduce both milk quality and milk productivity. The relationship between SCC in milk and milk production of Black-and-White cows was studied. The results are shown in Table 1.

Milk SCC data were divided into 6 classes, and their impact on the milk production of the cows in the first lactation was evaluated. The results showed differences between levels of SCC and milk production. Cows in a higher class for SCC showed lower milk production per lactation. All the differences of the milk yield between classes of SCC were statistically significant ($P < 0.001$).

According to the results of the study, the increase in SCC from 100,000 to 800,000 cells/ml and above

Table1. The production of Black-and-White cows depending on milk SCC in during lactation.

The levels limit of SCC		%			
Group	SCC, thousand/ml	of cows	Milk, kg	Milk fat, kg	Milk protein, kg
a	100<	22	4212*** ± 19.7ab	194.3 ± 6.73	140.6 ± 5.65
b	101-200	35	4580*** ± 21.7bc	196.9 ± 7.70	146.2 ± 6.42
c	201- 400	16	4472*** ± 20.2cd	182.3 ± 6.47	143.0 ± 6.66
d	401-500	8	4347*** ± 26.6de	180.3 ± 6.52	136.3 ± 5.73
e	501-800	9	4220*** ± 18.9ef	173.6 ± 5.16	134.0 ± 4.41
f	800>	10	3922*** ± 19.7af	168.0 ± 6.29	132.9 ± 7.01

P: ***<0.001, **<0.01, *<0.05.

decreased the milk yield of Black-and-White cows to 658 kg (14.4%), fat production - to 28.9 kg (14.7%), and milk protein production - to 13.3 kg (9.1%).

The udder and teat morphology of the cows was evaluated (Table 2). It was found that 57.8% of cows had intermediate strength or extremely snug and strong fore udder attachment; and 64.9% of cows had intermediate and extremely high udders. The analysis of the following traits of Black-and-White cows showed a measurable capacity of their udders. The preferable udder depth was in 73.8% of cows. Although a degree of udder depth is important for capacity, an extremely deep udder is susceptible to injury and mastitis. The udder cleft is especially vital to milking ease and minimizing of udder injury. An intermediate extremely strong udder cleft was present in 74.2% of cows.

Teats were located squarely in 69.1% of cows; the optimal teat length of 5 to 6 cm or 5 to 6 points was found in 86.8% of cows. The average teat thickness was 2.48 ± 0.01 cm (6.21±0.01 points). The data are presented in Table 2.

Assuming the observed traits of udder, the Black-and-White cows were evaluated on the count of somatic cell in milk.

The results shown in Table 3 and the Figure demonstrated the optimal evaluation of udder traits having positive influence on SCC in milk. Higher evaluated cows had lower SCC in milk.

The research has shown a significant impact of the fixed factors of udder and teat morphology on the SCC $\log_2$ in milk of Black-and-White cows SCC ($P < 0.001$).

Table 2. The average evaluation of udders in Black-and-White cows.

Trait	Optimal evaluation in points	Average evaluation in points
Fore udder attachment	9	6.04±0.01
Rear udder height	9	7.17±0.01
Udder depth	9	5.22±0.01
Udder cleft	9	7.23±0.01
Teat placement	6	4.81±0.01
Teat length	6	5.50±0.01
Teat thickness	5	6.21±0.01

Table 3. SCC in milk depending on the description of udder morphology.

Trait	SCC*1000/ml in milk on the description of udder morphology								
	1	2	3	4	5	6	7	8	9
Fore udder attachment	Extremely loose 1001±142.1	995±147.2	851±137.0	667±63.0	Intermediate strength 424±17.9	393±11.3	374±15.2	214±17.8	Extremely snug & strong 210±17.3
Rear udder height	Extremely low 1694±1058	1683±997	1254±1172	242±33.1	Intermediate height 369±55.2	435±23.6	395±10.8	399±13.8	Extremely height 203±12.0
Udder depth	Very deep udder floor well below hocks 456±20.6	213	345±44.3	466±21.6	Udder floor above hocks 395±10.9	388±16.1	368±28.9	251±51.8	Extreme height of udder floor above hocks 249±54.3
Udder cleft	Weak cleft 1642±210.1	1421±199.3	1247±212.2	503±69.4	Intermediate 533±37.7	505±25.0	404±15.0	350±10.4	Extremely strong cleft 282±25.7

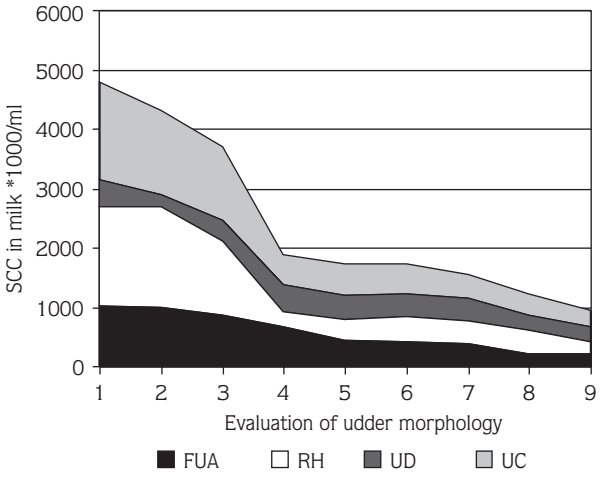

Figure. Influence of the udder traits on the SCC in milk.

The average evaluation of teat length of Black-and-White cows was near the optimal. This proved the population selection on the basis of teat length to be positive. Pearson's correlation coefficient between teat length in cm and SCC was slightly positive – 0.001; the correlation coefficient between teat thickness in cm and SCC was slightly negative - 0.001 ($P > 0.05$). According to the results (Table 4), teat length and teat thickness had no the impact on SCC in milk.

The results of evaluation of teat placement showed the cows with an extreme description of teat placement (extremely wide placement on outside of quarter or base of teats on extreme inside of quarter) to have the highest SCC in milk (906-1008 * 1000/ml). The lowest SCC in milk (375 ± 10.5 * 1000/ml) was determined in cows with teats placed centrally on quarters.

Discussion

Mastitis is one of the most costly and common diseases affecting dairy cows throughout the world.

Table 4. Correlation between milk SCC and teat morphology.

Teat traits, cm	Correlation coefficients	P
Length	-0.001	>0.05
Thickness	-0.001	>0.05
Placement	-0.210	<0.05

Disposition on mastitis is caused by the following factors: insufficient milking-out, irregular milking, rough and incorrect milking; injury to udder and teats, inappropriate zoohygienic conditions, high degree of milk yield, etc. (1,3,4,11).

Milk SCC is identified as an accurate indirect method to predict mastitis in dairy cattle and is one of the most important indicators for the milk quality and health of cows (5,6,9-11).

The negative relationship of SCC with milk production was reported by Koldeweij et al. (1), Philipsson et al. (5), Sender et al. (6), Rupp and Boichard (8).

Yalçin et al. (7) have determined a negative relationship between SCC and milk yield; the relationship between milk yield and lnSCC (natural logarithmic form) is not linear. The milk yield loss due to SCC was found to vary considerably with the level of SCC.

In the milk of healthy cows the SCC does not reach 100,000/ml. It increases sharply in cases of udder infection, due to the onset of local inflammation. A cow is considered to be sick with subclinical mastitis when the SCC in total amount of milk increases to more that 200,000/ml (1,9). The level of the SCC in milk has a direct correlation with udder health and a marked effect on milk production, milk composition and processing qualities of the milk (7,18). Mastitis milk contains a higher proportion of whey proteins and proteases, the latter breaking down milk proteins, which in turn results in lower cheese yields (1,3).

Losses of milk production caused by mastitis including separate udder quarters and disease progression were indicated by Philipsson et al. (5) and Sender et al. (6).

This study was carried out to investigate the effect of SCC on the milk production of Black-and-White cows. According to the results, the increase in SCC (from 100,000 to 800,000 cells/ml and above) decreased the milk production of cows from 9.1% (milk protein) to 14.4% (milk yield; $P < 0.001$) and 14.7% (milk fat; $P < 0.01$). The influence of SCC level on the milk protein was not statistically significant.

Monardes et al. (18), and De Jong and Lansbergen (19) found a significant relationship between udder size (suspension, distance from the floor, and shape of the udders and teats) and mastitis. Therefore, selection for decreased SCC, high udder suspension, shorter and more

closely located teats will lead to reduction in mastitis incidence and thus could to help farmers to increase their incomes (18,19).

Effects of udder and teat morphology on subclinical mastitis in cows were reported by the Turkish researchers Uzmay et al. (12). According to the research, Holstein cows with trough-shaped udders have the lowest risk of subclinical mastitis, whereas cows with pendulous udders had the highest risk. Teat morphology considering the risk of subclinical mastitis was the highest for cows with long and thick teats. The risk of subclinical mastitis for cows with funnel-shaped teats was found to be lower than that for cows with cylindrical teats.

After investigating the udder morphology of Lithuanian Black-and-White cows, the best quality milk according to the SCC was found in the groups of cows with the optimal description of fore udder attachment (extremely snug and strong), rear height (extremely high), cleft (extremely strong) and depth (extreme height) showing significant lower SCC in milk ($P < 0.001$).

The research revealed the positive impact of optimal evaluation of teat placement (teats placed centrally on quarters) on the SCC in the milk of the cows under investigation ($P < 0.001$).

The average evaluation of teat length of the Black-and-White cows was near the optimal; consequently teat length and teat thickness had no impact on SCC in milk.

The results of this study are consistent with the results of similar studies in regard to a negative relationship between SCC and milk yield during lactation and the relationship between somatic cell count and udder or teat morphology. The selection of Black-and-White cows based on the udder and teat morphology can improve milk quality.

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