The relationship between somatic cell count and linear type traits in Holstein cows

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Abstract

Test-day records of somatic cell count (SCC) and six linear type traits (fore udder attachment, udder depth, central ligament, rear udder height, front teat placement, teat length) of 22 613 first lactation Holstein cows from 117 herds were included into this study. SCC was log-transformed into somatic cell score (SCS). For each analyzed linear trait, the cows were assigned into three levels according to the linear type score: level 1 (score 1 and 2); level 2 (score 5 and 6); level 3 (score 8 and 9). A linear model was used to estimate the effect of different type traits on SCS. The highest values of SCS were found for the first levels. The differences between the first and second level were on average 0.33, 0.54, 0.28, and 0.36 for fore udder attachment, udder depth, central ligament, and rear udder height, respectively. Cows with deep udders, weak central ligaments and fore attachments, and low rear udder heights showed highest SCS. Low SCS appeared to be associated with intermediate distance between front teats and longer teats.

Keywords: cattle, linear type traits, somatic cell count

In most countries, dairy cattle breeding programmes are mainly oriented toward milk production traits with increasing concentration on conformation traits. Although these traits are of primary economic importance, functional traits such as longevity, fertility, and udder health are greater interest to producers to improve herd profitability. Among others, extreme emphasis on selection for milk yield may have negative effects on type traits that contribute to overall fitness. Research in the area of cattle breeding is more and more aimed at identifying new selection criteria which would contribute to the genetic improvement of economically important traits with low inheritance (as longevity or health traits). One of the possible solutions is to use indirect selection for these characteristics through selection of animal type traits (Bouška et al., 2006b).

One of the most important and accurate measures of udder health is the somatic cell count (SCC). Results of numerous studies showed that there exists an evident genetic relationship between somatic cell count and linear type traits, especially the udder traits (Van Raden et al., 1990; Short et al., 1991; Short and Lawlor, 1992; Misztal et al., 1992; Rupp and Boichard, 1999; DeGroot et al., 2002). Type traits and SCC are currently recorded systematically in a large portion of the cattle population. There is a great potential for improving udder health through selection on udder type traits eventually, perhaps with SCC, particularly when higher SCS (a logarithmic transformation of SCC) is genetically associated with higher occurrence of clinical mastitis (Philipsson et al., 1995; Rogers et al., 1998; Nash et al., 2000, 2002).

A generally favourable (negative) genetic relationship has been found between some udder conformation traits and SCC (Seykora and McDaniel, 1986; Rogers et al., 1991; Rupp and Boichard, 1999; Kadarmideen, 2004), with emphasis on udder depth and fore udder attachment. Genetic correlations indicated that cows with higher, more tightly attached udders and closer teats had lower SCC.

Reported environmental correlation estimates between these traits were usually low, close to zero (Rupp and Boichard, 1999). Phenotypic correlations between udder traits and SCC have been found variable, generally lower than genetic correlations (Mrode and Swanson, 1996), showing the same trend.

The objective of this study was to describe the relationship between udder conformation traits and somatic cell count in Czech Holstein cattle and to identify the traits suitable for selection for reducing somatic cell count in milk.

Material and methods

Monthly test-day observations of milk somatic cell count (SCC) were recorded for primiparous Holstein cows calved between 1998 and 2006. Type traits were evaluated by CMBA classifiers using the linear system of conformation evaluation. Six linear type traits (fore udder attachment, udder depth, central ligament, rear udder height, front teat placement and teat length) were included in the study. Data were edited to include only cows classified between the 30th and 210th day of the first lactation. Lactations with less than three records of monthly yield tests were discarded. The final dataset included first lactation records and type classification from 22,613 cows in 117 herds. The dataset was completed by the age of the cows and pedigree information. All records were obtained from the Czech-Moravian Breeders' Association (CMBA).

The monthly test-day observation of SCC was log-transformed into the monthly test-day observation (SCS) as $SCS = \log_{10} SCC$ (Mrode and Swanson, 1996).

To emphasize the tendencies between type traits and the somatic cell score and based on the method described by Bouška et al. (2006a), the cows were assigned to one of three levels for each analyzed linear trait: level 1 (score 1 and 2) representing the lower extreme; level 2 (score 5 or 6) representing mean value; level 3 (score 8 and 9) representing the upper extreme. Cows' classification for those traits which did not match any of the above-mentioned levels was discarded from the evaluation. The following scale for selected linear type traits was used (rated from 1 to 9):

fore udder attachment	-	weak and loose	*to*	extremely strong and tight
udder depth	-	below hock	*to*	shallow
central ligament	-	convex to flat floor	*to*	deep definition
rear udder height	-	very low	*to*	high
front teat placement	-	outside of quarter	*to*	inside of quarter
teat length	-	short	*to*	long.

The effects of the particular linear type traits on SCS were determined on the basis of the following linear model:

$$y_{ijklm} = \mu + S_i + R_j + O_k + H_l + \beta v + e_{ijklm}$$

where: y_{ijklm} = the test day record of SCS
S_i = fixed effects of the i^{th} herd of calving
R_j = fixed effects of the j^{th} year of calving
O_k = fixed effects of the k^{th} season of calving
H_l = fixed effects of the l^{th} group of the analyzed linear type trait
βv = fixed linear regression on the age at calving
e_{ijklm} = the residuum

The analyses were performed using the ordinary least squares methods in the GLM procedure of statistical software SAS® (SAS Institute, Inc., 2001).

Results and discussion

All the analyzed linear type traits (see Table 1) had a significant effect on SCS during the entire lactation with the exception of front teat placement and teat length. Teat length showed a significant influence on SCS only at the beginning and in the middle of lactation. Front teat placement had no significant influence on SCS in the last test day in lactation.

The estimated least squares means for levels of the particular linear type traits were plotted to identify trends for SCS. The results are presented in Figures 1 to 6. The highest values of SCS occurred mainly at the first level of the linear type trait. Subsequently the first level of particular traits was significantly different from the second and third levels for most of the analyses.

Fore udder attachment (see Figure 1) showed the highest value of SCS for the first level, weakly attached udders. SCS for the second and third levels were substantially lowest, with lower values for the third level.

Similar tendencies were found for udder depth (see Figure 2). The highest SCS appeared at the first level, i.e., deep udders. Both further levels showed much lower SCS, the lowest being for the third level.

As well, central ligament (see Figure 3) showed the highest SCS for the first level, i.e., cows with convex udders. The second and third level had the same values of SCS, considerably lower than the first level.

For rear udder height (see Figure 4) graphical analysis confirmed the highest values for the first level, a very low manifestation of the trait. Much less SCS was found at the second and third levels. High rear udder height, i.e., the third level, had the lowest values of SCS. The difference between the first level and the second level was on the average 0.33; 0.54; 0.28; 0.36 for fore udder attachment, udder depth, central ligament and rear udder height, respectively.

While the above mentioned traits showed similar trends for SCS, the next two traits, front teat placement and teat length, showed a different tendency. For front teat placement (see Figure 5) the analysis showed the highest SCS for the first level; teats outside of the quarter, the middle SCS; and for the third level, teats inside the quarter. The lowest SCS was found for the second level, teats in the middle of the quarter. The differences between levels were on the average 0.10.

The highest SCS related to teat length (see Figure 6) was at the first level, short teats. The SCS for the second and the third level were lower. Even though both levels showed similar values, the second level had lower values of SCS. The difference between the first level and the second level was on the average 0.18.

Pursuant to the results presented, we can conclude that the cows with deep udders, weak central ligaments and fore attachments and low rear udder heights showed the highest SCS. This is consistent with the results of Seykora and McDaniel (1986), who reported lower SCS for cows with higher udders and a deeper central ligament. Mrode and Swanson (1996) mentioned that phenotypic correlations between SCC and udder traits have generally been lower than genetic correlations, but they confirm the same relationships. Following genetic correlations, Boettcher et al. (1998) and Rupp and Boichard (1999) found deep udders and weak fore udder attachment associated with increased SCS. Similarly, Roger et al. (1991), DeGroot et al. (2002) and Kadarmideen (2004) concluded that selection for higher udders with tighter attachments would be favourable for reducing SCS.

Higher SCS appeared in cows with larger as well as smaller distance between teats. In accordance with our findings, Seykora and McDaniel (1986) reported higher SCS for cows with smaller distances between teats, while DeGroot et al. (2002) preferred closer teats as favourable for selection for lower SCS. Similarly, Roger et al. (1991) and Kadarmideen (2004) reported a negative genetic relationship between SCS and front teat placement.

The cows with shorter teats showed a higher value of SCS. On the contrary, Roger et al. (1991) found a positive genetic correlation between teat length and SCC.

Conclusion

We can conclude that chosen linear type traits (fore udder attachment, udder depth, central ligament, rear udder height, front teat placement and teat length) can be used as a positive criterion for the selection of cows with low somatic cell count in milk. Cows with higher udders, deeper central ligaments, tighter attachments, centrally placed teats with middle length are the most desirable.

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Tab 1: Statistical significance of F-test for analysed linear type traits

Month of lactation	Type trait					
	Fore udder attachment	Udder depth	Central ligament	Rear udder height	Front teat placement	Teat length
1	***	***	***	***	*	-
2	***	***	***	***	***	*
3	***	***	***	***	***	*
4	***	***	***	***	***	**
5	***	***	***	***	***	-
6	***	***	***	***	***	**
7	***	***	***	***	*	-
8	***	***	***	***	*	-
9	***	***	*	**	**	-
10	***	***	*	**	-	-

- P > 0.05 * P < 0.05 ** P < 0.01 *** P < 0.001

Fig 1: Least squares means of SCS for different levels of fore udder attachment during lactation

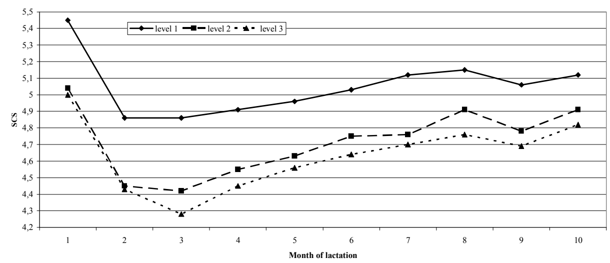


Fig 2: Least squares means of SCS for different levels of udder depth during lactation

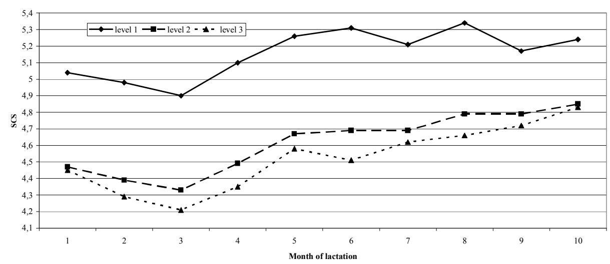


Fig 3: Least squares means of SCS for different levels of central ligament during lactation

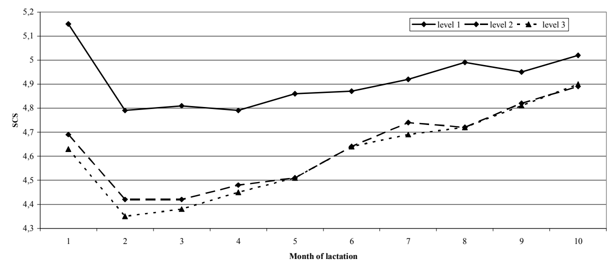


Fig 4: Least squares means of SCS for different levels of rear udder height during lactation

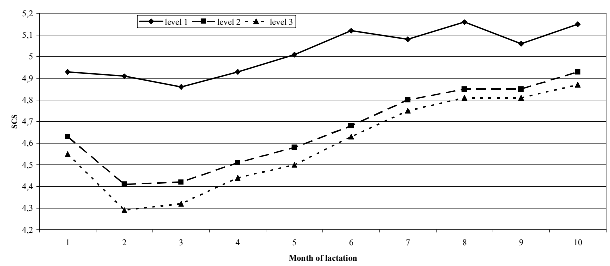


Fig 5: Least squares means of SCS for different levels of front teat placement during lactation

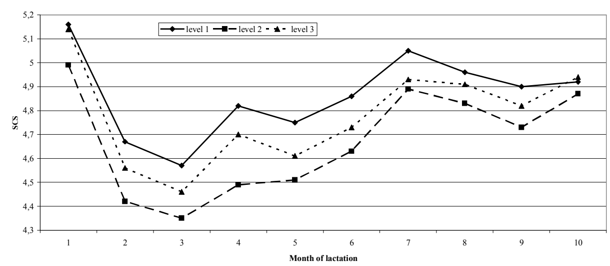
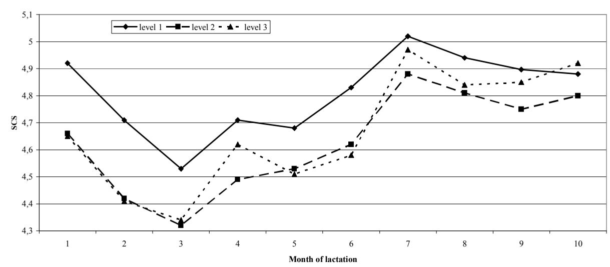


Fig 6: Least squares means of SCS for different levels of teat length during lactation



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