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Short communication: Associations between teat dimensions and milking-induced changes in teat dimensions and quarter milk somatic cell counts in dairy cows

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ABSTRACT

Although many studies have examined the relation between a wide range of factors and quarter milk somatic cell count (qSCC), including physical characteristics of the teat and changes in teat tissue due to milking, the effect of short-term, milking-induced changes in teat dimensions on somatic cell count has not yet been investigated. To identify teat dimensions and milking-induced changes in teat dimensions associated with qSCC, we conducted a longitudinal study ($n_{herds} = 6$, $n_{cows} = 72$, $n_{measurements} = 12$). Parity, stage of lactation, teat barrel diameter, and changes in teat barrel diameter during milking were identified as factors associated with qSCC. Teats with wider barrels had higher qSCC. Negative changes in the diameter of the teat barrel during milking (i.e., thinner teats postmilking compared with premilking) were associated with lower qSCC, whereas positive changes (i.e., thicker teats postmilking compared with premilking) were associated with higher qSCC. Selection toward more optimal teat characteristics may therefore result in improved milk quality and udder health. However, a threshold might exist for the maximum reduction in teat barrel diameter below which udder health is negatively influenced. If so, changes in teat barrel diameter might serve as an indicator for suboptimal milking and incorrect choice of teatcup liner or milking machine settings and thus help improve management of the herd.
Key words: dairy cow, teat dimension, quarter milk somatic cell count

Short Communication

Mastitis is one of the most common and costly diseases in dairy cattle (Halasa et al., 2007). During IMI, SCC increases as part of the inflammatory response. In the absence of clinical symptoms, measurement of the SCC is the most frequently used indirect measure to detect subclinical mastitis (Beaudeau et al., 2002). Many studies have examined the relation between managerial, environmental, cow, and quarter factors, including the physical characteristics of the teat, and SCC. Teat length was not significantly associated with SCC (Seykora and McDaniel, 1986; Coban et al., 2009), whereas SCC generally increased with increasing teat diameter (Seykora and McDaniel, 1986; Chrystal et al., 1999). One study, however, reported the absence of an association between SCC and teat diameter in Gir cows (Porcionato et al., 2010). It is well known that machine milking induces changes in teat tissue (such as congestion and hyperkeratosis) and in teat dimensions. Although changes in teat tissue, such as teat thickness and teat end callosity, have been associated with udder health (Zecconi et al., 1996; Neijenhuis et al., 2001) and guidelines for acceptable changes in teat end thickness have been formulated (Hamann and Mein, 1996), no studies have actually examined the effect of changes in teat dimensions on udder health. The objectives of this study were to examine potential associations between teat dimensions and short-term, milking-induced changes in teat dimensions and quarter milk SCC.

A longitudinal study including 72 Holstein-Friesian cows from 6 Flemish dairy herds was conducted between June 2008 and May 2009. Over 1 yr, teat dimension and quarter milk somatic cell count (**qSCC**) measurements were performed monthly. Per herd, a cohort of 10 clinically healthy cows (assessed by visual inspection of the animal, udder, and milk) was randomly selected within parity blocks (4 heifers, 3 cows of second parity, and 3 cows of third or higher parity) at the beginning of the study. Before the end of the study, 18 out of 60 cohort cows were culled (ranging from 0 to 5 per herd) for a diversity of reasons, including problems with lameness, udder health, fertility, or milk production. All cohort cows culled before the 11th month of the study (n =

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12) were replaced by randomly selected herd mates of the same parity. Based on the data of May 2009, the average herd size was 70 Holstein cows (ranging from 49 to 78), with an average production of 9,368 kg of milk per cow per year (ranging from 7,147 to 11,665). Cows were milked twice a day with round, narrow-bore liners on 2 farms and round, medium-bore liners on 4 farms. Automatic cluster removal was used on all farms. The herd vacuum level averaged 42.0 kPa and ranged from 41.2 to 42.9.

Quarter milk samples were collected and SCC was determined by means of a Fossomatic 5000 FC (Foss, Eden Prairie, MN). A natural logarithmic transformation of qSCC (**LnqSCC**) was performed to obtain a normal distribution.

Within 15 d before and 15 d after qSCC recordings, teat dimensions (length and diameters) were determined using a 2-dimensional vision-based measuring technique (Zwertvaegher et al., 2011) immediately before and after evening milking. All pictures were analyzed using a software program to determine teat length and teat diameters at 3 different heights of the teat; that is, at 75% (further referred to as the teat base), 50% (teat barrel), and 25% (teat apex) relative to the teat end. Absolute and relative changes in teat length and teat diameters due to milking were calculated. This resulted in 16 different teat dimensions available for further study: teat length, teat diameter at teat base, teat barrel, and teat apex, respectively, as measured pre- and postmilking, as the absolute changes [postmilking value – premilking value], and as percentage changes relative to the premilking value [(postmilking value – premilking value)/premilking value × 100].

A 4-level (herd, cow, quarter, and observation) model was fit with LnqSCC as the dependent variable using SAS 9.3 (SAS Institute Inc., Cary, NC). Herd, cow, and quarter were included as random effects to correct for clustering of cows within herds, quarters within cows, and repeated measurements within quarters, respectively. Measurement was forced into all models as fixed effect to model the repeated measurements. The covariance between repeated measurements was modeled using the auto-regressive (1) structure.

The regression-model building process involved several steps as described previously (De Vliegher et al., 2004). In addition to the 16 different teat dimensions, the effects of parity (1, 2, 2+), stage of lactation (0–30, 31–60, 61–120, 121–180, 181–240, 240+ DIM), and quarter position (front, hind) on LnqSCC were assessed. First, univariable associations were tested between all independent variables (16 teat dimensions, parity, stage of lactation, and quarter position) and LnqSCC. Statistical significance in this step was assessed at $P < 0.15$. Second, Pearson correlation and Spearman correlation coefficients were calculated among the significant independent variables to avoid multicollinearity. If 2 variables had a correlation coefficient ≥0.6, only one was selected for further analysis. In a third step, multivariable models were fit using a backward stepwise procedure at $P < 0.05$. Finally, the relevant 2-, 3-, and 4-way interactions were tested between the fixed effects included in the final model, and removed in a backward stepwise manner when nonsignificant ($P > 0.05$). Least squares means (LSM) were calculated for the independent variables in the final model. The fit of the final model was evaluated by examination of the normal probability plots of residuals and by inspection of the residuals plotted against the predicted values.

Descriptive statistics (mean, standard deviation, and range) for the 16 different teat dimensions are presented in Table 1. The increase in teat length due to milking averaged 9.2% but both shorter and longer teats postmilking occurred (up to 25.6% decrease and 64.4% increase). The average relative changes in diameters were close to zero but changes postmilking compared with premilking varied widely (e.g., −24.8 to 45.4% for diameter at the teat base). In Table 2, the geometric mean qSCC per quartile of the different teat dimensions are shown. The largest proportion of variation in LnqSCC, as studied using a 4-level null model (no fixed effects included), resided at the observation level (62.2%), followed by the quarter (20.3%), cow (13.5%), and herd levels (4.1%), respectively. Including the significant fixed effects in the model explained 20% of the total variance of LnqSCC.

Similar to results of other studies (Reneau, 1986; Bartlett et al., 1990), LnqSCC increased significantly with parity and followed a nonlinear curve over lactation stage (Table 3). Moreover, LnqSCC significantly increased with increasing diameter of the teat barrel (Table 3), corresponding with previous findings (Higgins et al., 1980; Seykora and McDaniel, 1986; Chrystal et al., 1999). Quarters with larger teat diameters tended to have more clinical and subclinical mastitis (Hickman, 1964), and larger than herd-average teat diameter was identified as risk factor for mastitis by Slettbakk et al. (1995). Larger diameter teats tend to have larger teat orifices and wider teat canals (Rathore and Sheldrake, 1977; Chrystal et al., 1999), which may explain the association between teat diameter, SCC, and mastitis. Some authors, however, found no relationship between teat diameter and SCC (Porcionato et al., 2010), IMI (Bakken, 1981), or mastitis prevalence (Binde and Bakke, 1984). Different methods of measuring teat dimension, different definitions of mastitis and IMI, differences between statistical analyses, and breed may explain the contradictory results.